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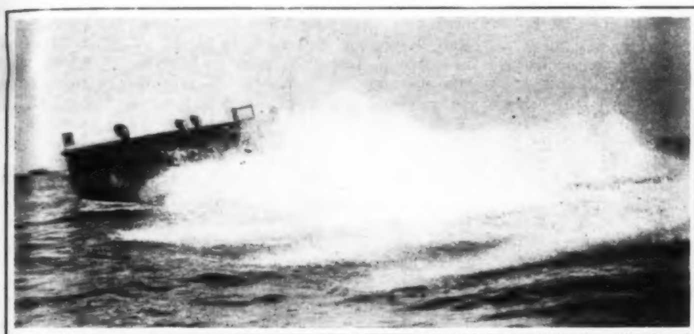
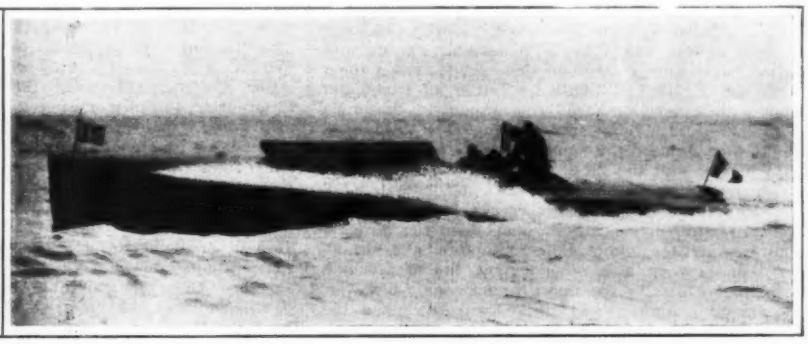


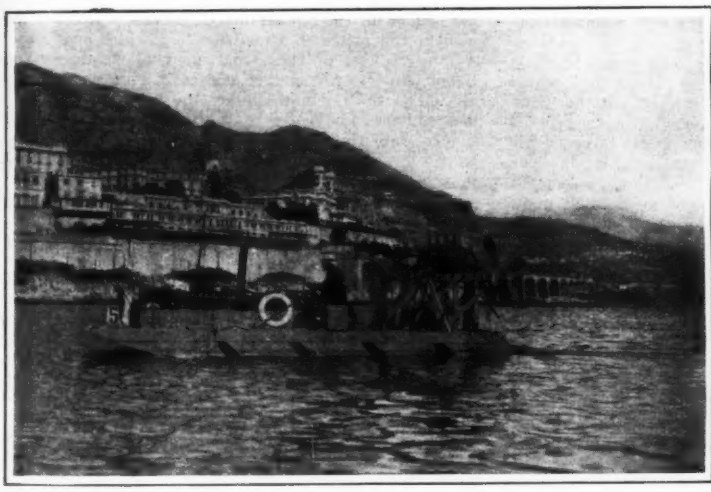
THE ITALIAN RACER "FIAT XV."

A 26-foot cruiser fitted with an 8-cylinder engine which drove it at the phenomenal speed of 32.34 miles per hour in the 31-mile race.



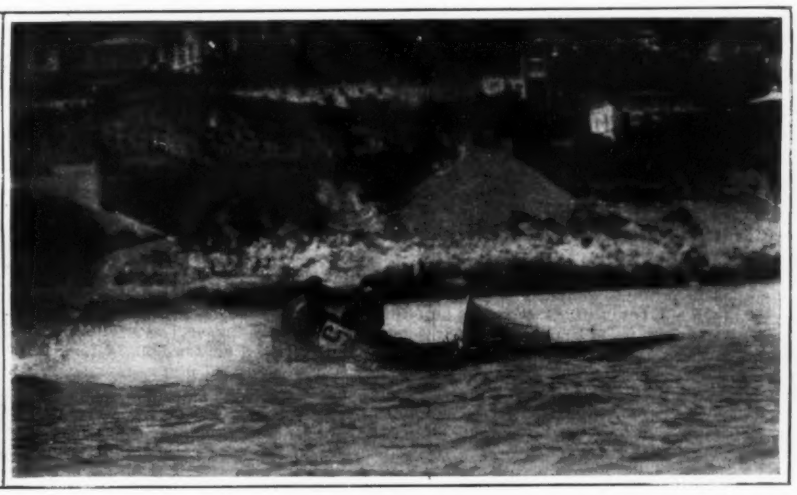
THE FRENCH RACER "PANHARD-TELLIER."

The speed champion of the fleet. Fitted with twin screws and two 4-cylinder engines of 135 horse-power each, this boat averaged 35 miles per hour in the 124.27-mile race and set a new mark for speed and endurance.



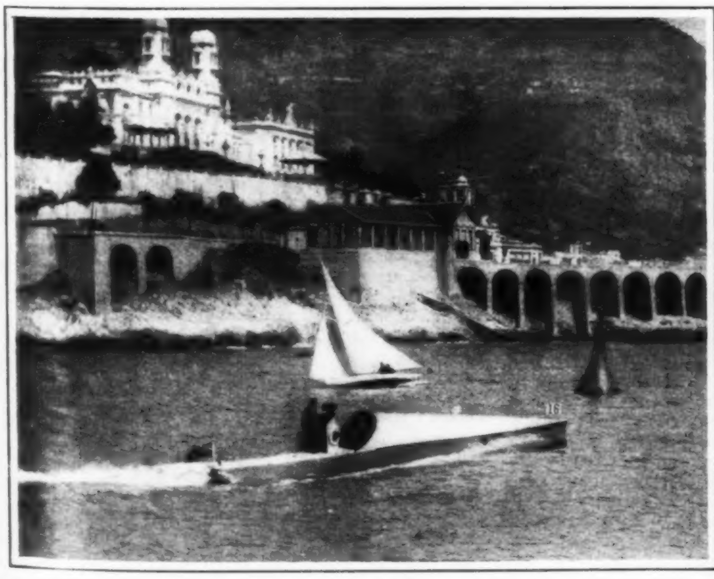
COUNT DE LAMBERT'S LATEST FORM OF HYDROPLANE BOAT.

It consists of 5 pontoons with inclined bottoms. A 50-horse-power, 8-cylinder V-motor, driving a 3-bladed air propeller, sends this boat along over the water at a speed of from 20 to 25 miles per hour.



THE "OBUS-NAUTILUS" GLIDING BOAT RUNNING AT FULL SPEED.

This small craft has a bottom consisting of two inclined planes and is fitted with a 12-horse-power motor. It covered 6¼ miles at a speed of 20¼ miles per hour and 1 kilometer at 26.86 miles per hour.



THE ENGLISH RACER "FLYING FISH."

Finished fourth in the long-distance race. Average speed 23.7 miles per hour. This boat was fitted with twin screws and two 80-horse-power, 4-cylinder, Wolseley-Siddeley engines.

THE FRENCH THIRD-CLASS CRUISER "ULYSSE."

Winner in the 31-mile race for its class. Average speed, 23.72 miles per hour. The "Ulysse" is a 40-foot boat fitted with Panhard engines having a cylinder capacity of not over 457.66 cubic inches.

© FAST AND NOVEL MOTOR BOATS AT THE FOURTH ANNUAL MEET AT MONACO.

THE FOURTH ANNUAL MOTOR BOAT EXHIBITION AND RACES AT MONACO.

By Our Paris Correspondent.

For the fourth time there were held at Monaco, from the 2d to the 14th of last month, the motor-boat show and races that have come to be the great annual spring event in Europe. The boats exhibited by the different constructors were finer, speedier, and more beautifully finished than ever before, and many records were broken in both the racer and cruiser classes. As an indication of the trend of motor-boat development abroad, it may be said that whereas in 1904 there were entered for the races but 81 motor boats (34 racers, 34 cruisers, 4 steam yachts, 7 small boats, and 2 fishing boats), this year 93 craft were entered, consisting of 22 racers, 54 cruisers, 5 hydroplanes, and 12 vedettes. Thus it will be seen that the fishing boats and the small boats have been replaced by the hydroplanes and the vedettes.

Two races were held on the 8th of April, one for the racers, and the second for the cruiser class. The distance in each case was 50 kilometers (31.06 miles). These racers were of the first series, consisting of boats up to 8 meters (26.24 feet) in length. French and Italian boats were entered in this series, among them being the "Rapière II.," built by Tellier, of Paris, and fitted with a new Panhard-Levassor motor; Baron de Caters' "Sea Sick," the speed champion of last year, which was built by the same firm and fitted with an Itala motor; and the "Itala," both hull and motor of which were of Italian make, as was also the "Fiat XV." "La Mouvette" was another French racer built by Tellier. In all, five boats started. Soon the struggle came between the two favorites, "Rapière" and "Fiat," and they kept close together during the first round. "La Rapière" made the finest performance, however, and ran at a high speed, taking the turns about the buoys in much better shape than the Italian boat. After the first round, the "Fiat" seemed to have trouble with the motor, and slowed up for a short time. It soon came up to speed, however, but the French boat had already passed far in the lead, while the "Sea Sick" was running second. The "Itala" was obliged to stop, as the water feed pipe was above the water level when the boat ran at high speed. The "Fiat" gained upon the "Sea Sick" again, as it was making faster speed, and succeeded in overtaking and passing her on the fifth round. It completed the course in less than one hour, taking second place, while the "Sea Sick" followed closely at a somewhat lower speed. As regards the "Fiat" it was one of the fastest boats in the race, but was more difficult to handle when making the turns. It threw a tremendous spray, as can be seen from the photograph. The "Sea Sick," which was built over a year ago, is a fast as well as a reliable boat, and its Itala motor made a fine performance. But the palm was carried off by the "Rapière II.," the fastest boat of the lot, and which brings much credit to the Tellier firm and the Panhard motor. The result of the 50-kilometer (31.06-mile) race was as follows: "La Rapière II.," first in 55 minutes, 55 1-5 seconds, which corresponds to a speed of 33.32 miles an hour—a new world's record that is truly remarkable for a boat of this size; "Fiat XV.," second in 57 minutes, 36 seconds (32.36 m. p. h.); "Sea Sick," third in 1 hour, 1 minute, 50 seconds; and "Mouvette," fourth in 1 hour, 50 minutes, 59 4-5 seconds.

On the same day, in the morning, was held the 50-kilometer (31.06-mile) race for the small cruisers, and nine of these succeeded in finishing the distance. There were no less than 21 boats at the start, these belonging to the first series, with a length under 6.50 meters (21.32 feet), and a cylinder capacity not exceeding 2.5 liters (152.55 cubic inches). The best places were taken by "Capoulou III.," and "Nautilus-Mutel I.," both of which were fitted with Mutel motors. After the start "Capoulou" took the lead, but was hard pressed by "Nautilus-Mutel," and the two cruisers kept well together during the whole race, making a very regular run, and at a good speed, this being about 19½ miles an hour. A good performance was also made by the "Gamine," fitted with a Peugeot motor, and it made nearly the same speed, taking the third place. Fourth came the "Champagne," with an Antoinette motor, and these four boats all succeeded in breaking last year's record at Monaco. The "Lanturlu III.," fitted with a De Dion motor, was fifth. The times were as follows: 1. "Capoulou III.," 1 hour, 35 minutes, 55 2-5 seconds (19.43 m. p. h.); 2. "Nautilus-Mutel I.," 1 hour, 36 minutes, 11 4-5 seconds (19.37 m. p. h.); 3. "Gamine," 1 hour, 39 minutes, 28 seconds (18.73 m. p. h.); 4. "Champagne," 1 hour, 51 minutes, 56 seconds; 5. "Lanturlu III.," 1 hour, 58 minutes, 19 seconds; 6. "C. B. II.," 1 hour, 59 minutes, 47 1-5 seconds.

On the second day of the races there was such a high sea that only the most seaworthy craft could run, and the high speed racers were obliged to wait for more favorable weather. Some of the cruisers were able to stand the sea and did very well on this occasion, showing that the designs are becoming much better in this respect. At the start were the "Louise-Reine," "Mais-je-vais-piquer," "Nautilus B. V. Jacqueline," "Excelsior Nihil-Lally," and "Dalifol-Petroleum," all in the second class with length below 8 meters (26.24 feet), and a cylinder capacity of not over 3.75 liters (187.64 cu. in.). The "Nautilus B. V. Jacqueline" took the lead from the start, with the Swiss "Mais-je-vais-piquer" coming next; but unfortunately the "Nautilus" struck against a piece of floating wood and was damaged, springing a leak and being obliged to stop. The latter boat thus came in first at the finish, with "Dalifol-Petroleum" second. Owing to the bad state of the sea, the race was declared off before the rest of the boats had come in, and the "Dalifol" had not as yet reached the finish. This boat was run on kerosene and was not eligible because of excessive cylinder capacity. The time made by the "Mais-je-vais-piquer" was 1 hour, 38 minutes, 34 3-5 seconds, which corresponds to an average speed of 18.9 miles an hour. The "Nautilus" was doing better than 20 miles an hour when it met with its accident. This boat was fitted with a Boudreaux-Verdet compound-piston motor, which was described some time ago in Supplement No. 1597. The Swiss craft had a Picker motor in a Mégevet hull.

The cruiser race for the fourth class, i. e., for boats between 12 and 18 meters (39.37 and 59.05 feet) in length, and having a cylinder capacity of not over 15 liters (915.33 cubic inches), brought out the heaviest boats of the lot, and some high speeds were made in this event, notwithstanding the high sea. At the start were the "Lorraine," with two Lorraine-Dietrich motors driving twin screws, and the Italian cruisers "All 'Erta" and "Florentia," the former with a Fiat motor and the second with a Florentia motor. Slower boats were the "Martini IV.," and the "Nautilus-Mutel III." The "Lorraine" came rapidly to the front, and made a brilliant run, breaking the world's record for cruisers. After a struggle between the "All 'Erta" and the "Florentia," the former came in ahead, while the other two craft, "Nautilus" and "Martini," abandoned the race. The time made by the "Lorraine" for the 50 kilometers (31.06 miles) was 1 hour, 14 minutes, 21 1-5 seconds, which is a speed of 25.05 miles an hour, that brings it nearly into line with the racers.

Both racers and cruisers had a hard time on the 10th of April, as the sea was very high and made it almost impossible for most of the boats to continue the race. Only two were able to finish, these being the "Panhard" and the "Mercedes." But the "Panhard" made by far the best performance, and what was surprising, succeeded in breaking all the previous records for 50 kilometers (31.06 miles), making even better time than the "Rapière" in the preceding race. At the start the "Panhard" led off, followed by the "Jeannette," "Daimler I.," "Daimler II.," "Flying-Fish," "New Trèfle" and "Mercedes." The "Panhard" soon took the lead and kept it during the whole of the eight rounds of the race. After the fifth round all the boats but the "Mercedes" had dropped out, as they were unable to stand the waves, and some of them suffered considerable damage. The "Mercedes," which is a slower boat, kept up very regularly, but the "Panhard" was away ahead, and finished the race in 54 minutes, 27 seconds, which is the world's record for this distance, being a speed of 34.21 m. p. h. The "Mercedes's" time was 1 hour, 42 minutes, 56 seconds.

The "Daimler III." and "II." are of English make and have 2 and 3, 90-horse-power, 6-cylinder motors respectively, each driving separate screws. The other English boat, "Flying Fish," has two powerful 80-horse-power 4-cylinder Wolseley-Siddeley motors. These boats were built by Saunders. The last-named hull was known last year as the "Yarrow-Napier." Piloted then by Lord Montague, it made 50 kilometers in 4 hours, 47 minutes, as against 5 hours, 14 minutes, this year.

Much attention was attracted by the gliding boats, or hydroplanes, and there were three of these of different designs to be seen. Count de Lambert's new craft, the "Glisseur," is made up of a series of box-like compartments 3 meters (9.84 feet) long by 1 meter (3.28 feet) wide and spaced about a foot apart. Each compartment has an inclined surface underneath, and the whole appears like a large raft. The total weight is 1,000 kilogrammes (2,204 pounds). Upon the platform, mounted high up in the air, upon a suitable framework, is an 8-cylinder Antoinette motor capable of developing 50 H. P. at 1,000 R. P. M. The motor carries a large 3-bladed propeller on its crankshaft, and the push obtained from this working in the air serves to drive the boat. The propeller is 2.1 meters (6.89 feet) in diameter. It drives the boat at a speed of about 25 m. p. h., and raises it from a submergence of 10 inches to one of barely 2 inches. This method of propulsion is by no means new, it having been used some years ago by Count Zeppelin. As to the other gliders, they are both constructed according to Count de Lambert's patents. One of these is the "Obus-Nautilus," which is a miniature craft holding two persons. Its appearance will be noticed in one of the views. Another, the "Motogodille," carries a light combination motor and propeller outfit that can be detached from the boat, according to the system we already have had occasion to describe. There was a special race for the three hydroplanes. Count de Lambert's craft was disabled from the breaking of a gasoline pipe. It caught fire and had to abandon the race soon after the start. The "Motogodille" also had an accident and dropped out, but the "Nautilus" made a fine run and succeeded in covering the 10 kilometers distance (6.21 miles), bounding over the waves in a remarkable manner. It covered the distance in 18 minutes, 24 seconds, or at a speed of 20¼ miles an hour.

The fourth day's race for cruisers of the third class, measuring from 8 to 12 meters (26.24 feet to 39.37 feet) was distinguished by the performance of the Mors-motored "Ulysse" and "Le Sec," and the "Gallinari II.," and "Adèle," which had Delahaye motors. Last year's time for the 31.06 miles was 1 hour, 28 minutes, 25 seconds, but this year the winner, "Ulysse," made the run in 1 hour, 18 minutes, 33 seconds with great regularity at an average speed of 23.72 miles an hour. There were fifteen starters on this occasion.

The long-distance race, known as the "Championship of the Sea," was run on the 12th of April, with fine weather and a smooth sea favoring the event, and it was one of the most interesting of the series. The distance was 200 kilometers (124.27 miles). At the start, the "Rapière" led off, followed by "Panhard," "Flying Fish," "Fiat XV.," "Lorraine," "All 'Erta," "Le Sec," "Ulysse," "Adèle," "Florentia," "Mais-je-vais-piquer," "Mercedes II.," "Excelsior" and "C. B. I." Both racers and cruisers entered the event this time. The "Panhard" took the lead from the start, and succeeded in keeping it up to the finish. At first the "Rapière" and "Fiat" came next, and the boats kept in this order during the first three rounds. In the fourth round the "Rapière" fell out owing to a mishap to the magneto, allowing the "Fiat" to come second. This order lasted until the seventeenth round, when the "Fiat" was obliged to abandon the race. There was an exciting struggle between the "Ulysse" and the "Sec," but the "Sec" was disabled during the fifteenth round. As to the "Lorraine," it had to abandon the race owing to a hot bearing, and was then passed by the Italian boat, "All 'Erta." During the race the "Adèle" kept gaining upon the "Mercedes," and finally took fifth place, while the "Mercedes" fell back to sixth. The result of the race was as follows: Winner, "Panhard," which made the distance in 3 hours, 33 minutes, 4 seconds, at an average speed of 34.99 miles an hour; 2. "All 'Erta," time 4 hours, 46 minutes, 27 seconds; 3. "Ulysse," time 4 hours, 59 minutes, 49 seconds; 4. "Flying Fish," time 5 hours, 14 minutes, 13 seconds; 5. "Adèle," time 5 hours, 16 minutes, 3 seconds; 6. "Mercedes," time 7 hours, 55 minutes. As will be noted, the performance of the "Panhard" is a remarkable one, seeing that it kept up a speed of over 30 knots during three hours, this being the highest speed ever made by any motor boat and by any craft whatever except some of the swiftest torpedo boats with powerful steam turbines. The regularity of running of the "Panhard" was also noticed during the race, and on the whole it made a most brilliant performance.

CLOTH FROM PAPER.

Several months ago there appeared in American trade papers a brief description, taken from a German newspaper, of the appearance of garments for men and women the principal constituent of which was paper. At the request of the Department of Commerce and Labor, American consular officers in Saxony, in which section of the German Empire the paper makers were located, were instructed by the Department of State to inquire into the correctness of the reported discovery. In response the following report has been furnished by Consul Carl Bailey Hurst, of Plauen, who also furnished the Bureau of Manufactures with samples of the paper textiles:

To the ingenuity of a well-known Saxon inventor and manufacturer, Herr Emil Claviez, is due the production of a paper yarn, termed "xylolin," that has been successfully used in a wide range of textile fabrics. The utilization of paper wood fiber in this new and practical way and the extreme cheapness of the new material compared with other yarns now in use is really a remarkable achievement. It should be said that this is not a haphazard discovery, but rather the logical result of years of painstaking study and experimentation. After the final development of the theory at first in mind into tangible material for all manner of uses in textile industries, the paper thread and yarn, loose or tightly spun, of all thicknesses, have since been woven into almost every conceivable fabric and tested and retested, until the invention has become an important commercial success. The paper yarn has extraordinary wearing properties, and as the full scope of its usefulness has probably not been determined, it will, in all likelihood, lend itself to other purposes yet to be discovered.

It should be understood that xylolin is wood fiber spun into a paper thread or yarn, and may be woven into any desired fabric. Although of the same material as paper, xylolin is not used in sheets and has nothing whatever of the nature of papier-maché or any substance such as may be molded or cut in blocks. It is primarily a thread or yarn and is employed exclusively in weaving. The looms used in the manufacture of most textiles do not have to be especially constructed for this substance, although they may have to be slightly adapted for its readier manipulation. A carpet loom of almost any kind can employ this new yarn. A loom that is used for weaving linen or cotton fabrics of fine or loose mesh can readily take the finer kinds of the paper thread. The thread is not brittle, it does not have a hard surface, and it neither shrinks nor stretches to any appreciable extent. Having certain resilient qualities, it can not be readily crushed or dented like paper, and on it moisture has practically no effect. It is a serviceable substitute for cotton, jute, linen, and even silk. When bleached the yarn or thread is of a snowy whiteness, and at first glance can not be distinguished from cotton. It can be woven to appear as homespun linen. It combines the good qualities of cotton and linen at one-third of the price of cotton and one-tenth of the price of linen.

Being paper, it can be more readily dyed in delicate shades, far outmatching the range of colors to which cotton or silks are susceptible and vastly more than those of linens. The process of dyeing the thread or yarn is patented, and appears to be of such perfection that no colors, from the daintiest nuances to the richest hues, are affected by strong light. If it should be the wish of a manufacturer to combine the paper thread or yarn with other materials to gain the cheap-

ness of the new substance, it can be readily done. It can be run in greater or less quantity as may be desired. Ninety-five per cent of the material used in the thread is cellulose, such as is used for newspapers, and 5 per cent cotton, but of course subjected to entirely novel treatment before spinning. The crude materials in this proportion are consequently very cheap compared to other vegetable fibers used in weaving, and this alone will make its place in the textile market permanent. Already factories are busily at work in England and in Bohemia, as well as in Saxony, turning out the paper thread and yarn, which is bought by textile manufacturers for use in their mills. It is the business of the inventor to supply the spun paper and not, with the one exception of floor coverings, to make up the multitude of articles which can be woven from xylolin.

Among the various fabrics in which the greatest amount of work has thus far been accomplished is the making of rugs and carpets, and at the factories of the inventor paper floor coverings are woven in great quantities, and are already being exported to the United States and elsewhere with marked success. Here the yarn of heavier quality, woven into beautiful designs, is found to possess advantages over certain classes of floor coverings. They can be turned out in any thickness as rugs, mats, or carpets. They are elastic to tread, do not retain dust readily, and are easily cleaned by beating or washed without fear of injury. Unpalatable to moths, they are not eaten by these insects. The paper floor coverings naturally do not possess the properties of rich Persian carpets, but are adapted to uses to which oriental rugs can be ill put. Although they can be made in pile, they are at present manufactured chiefly after the manner of an ingrain carpet, but in finely wrought, artistic patterns. They are clean and fresh, and particularly suited to summer homes and veranda use.

Another great field for the paper yarn is in the manufacture of bagging, being a practical substitute for the more expensive jute. It has been found best, however, in making sacks to mix one thread of jute with two of paper. The combination secures the advantages of jute gunny cloth and the lightness and cheapness of wood paper. Closer woven, equally strong, and at one-half of the cost, it can replace with advantage the jute sacking now in general use. Inasmuch as the production of jute is localized and the demand for it steadily increases, xylolin used in place of jute for sacks will make those who have hitherto used jute sacking in large quantities more or less independent of the jute market, with the high prices now prevailing. Sacking made of the combination of xylolin and jute seems to be a cleaner and a neater fabric and not as heavy. The output of this combination paper sacking is already of great proportions, and it is estimated that in the near future the new sacking will be a formidable rival of the jute now in use the world over.

The spun paper fiber has been woven into outing hats for men and women. "Canvas" shoes and slippers have been made of it at nominal cost. Some idea of its adaptability for towels may be gathered from the fact that last year alone 7,000,000 pieces were made and sold, and it is likely that not one purchaser in a hundred but thought he was buying linen toweling at bargain prices. These are wholesaled at about 24 cents a dozen, medium size. It should not be thought that the new fiber is put upon the market as a crafty imitation, but makers of many sorts of textiles have found it so serviceable that they use it for mixing with other thread and yarn or weave it alone.

Wonderfully successful have been the essays in making wall hangings and furniture coverings. When used for mural decoration, the material may be either nailed or applied with paste, and the delicate coloring that the paper fiber takes renders the effect of the tapestries singularly effective. For upholstering veranda furniture the material has an unusual advantage beyond its merits of decoration because it is not subject to injury by light or dampness or even by rain.

For certain grades of wearing apparel the new paper fiber has in itself an important sphere. The readiness with which yarn can be made up into cloth of any design or shade makes its use in this regard easy and successful. One peculiar feature when the paper thread is used in garments for clothing of medium thickness is the resultant warmth. It possesses the advantage of lightness in comparison with an equal bulk of linen or even cotton. The cost of the material for a full three-piece suit of clothes of average weight is not over $1. In lighter weights it is particularly adapted to outing costumes. It can be made to look like a good grade of ducking and is an excellent material for wear in the tropics. For workmen's jackets and blouses and overalls it can be made up in brown and blue at half the cost of the material usually employed. There have been articles in the market made of tough, narrow strips of paper sewed together, making vests and light jackets to be worn under other clothing, retaining the warmth of the body, but allowing little or no ventilation. This has nothing in common with xylolin. The new paper fiber, however, being woven, possesses sufficient porosity to make a hygienic garment. It seems well suited for underwear. In consideration of the fact that loosely woven underclothing is replacing to a certain extent the heavier flannels of an older generation, the paper fiber has been found to be very serviceable, combining warmth and lightness, and is fine enough to be worn by the youngest children.

Although there seems to be no limit to the uses to which the paper yarn can be put, fashion will have to take up the new material before it can be worn as gentlemen's and ladies' clothing. While possessing most of the good qualities of fashionable stuffs, it may lack in finish and style the appearance of finer grades of woolen goods; but it really makes little difference whether the paper-woven garment becomes the vogue or not, as its many admirable qualities, coupled with excessive cheapness, are bound to make it an article of practical and far-reaching beneficence.

The process of preparing the new thread and yarn is a secret one and is patented in all civilized countries. It is of interest to note that the inventor intends starting mills in the United States, where the necessary raw material is abundant and of fine quality.

A full line of samples of the paper textiles referred to, as far as made at the inventor's mills, has been forwarded by me to the Bureau of Manufactures for the inspection of American manufacturers and others interested.

SLAKING OF PLASTER AND MEANS OF RETARDING ITS HARDENING.

FOLLOWING are a few hints from practice for the slaking of plaster that will be found well worthy of consideration.

In preparing plaster for casting and modeling purposes, there are some points that should always be observed:

1. The water should never be poured on to the plaster, but invariably the plaster should be poured into the water and then stirred as rapidly as possible into a paste, in which no little lumps of unincorporated material can be detected. If the opposite method is adopted, not only will the plaster paste be lumpy and require prolonged stirring, but it loses through this and on account of uneven saturation with water part of its setting property.

2. The plaster should never be poured into the water in too large a quantity at one time, so that the strength of the mixture can be better determined and it is not necessary later to add more water. This after addition of water is most likely to prove injurious if the mass has already entered into the setting condition. The setting process is thereby injuriously affected and perfect hardening prevented. The dried mass will not be as hard and under some circumstances is likely to prove friable. The proportion of water to ground gypsum is not exactly determinable, much depending on the kind of rock from which the plaster was obtained, at what temperature it was burned, whether it was fresh or had been kept for some time and even on the character of the water. In mixing small quantities it is best to have the water in a suitable vessel and to scatter the plaster, allowing it to run through the fingers, on to it. For casting, the plaster must be submerged until it reaches the surface; not until then must it be stirred and the stirring must be from the bottom upward until no more lumps appear. If it is desired to have it set quickly and produce as quickly as possible a hard mass, the stirring in and using must be done all the quicker. If, however, it is desired to have it remain, after setting and hardening, in a moist condition for a long time so that it can be formed with the help of the modeling tools, a little longer time may be allowed for the preparation, but this must not apply to the rapidity of stirring, which must be done quickly to insure the complete and uniform absorption of water.

3. The longer the plaster is stirred the more its setting properties suffer. They can even be entirely destroyed, so that only a foamy mass remains that will harden at best into a very friable substance. When very rapidly mixed, the plaster is never perfectly white if it is poured at once into the molds. If, however, we allow it to stand a few moments or stir it only very gradually toward the end, it will "rise" and gain in whiteness and fineness. If we notice that after standing a dirty scum forms on the surface, this, where the fineness of the pouring is a consideration, must be removed with a spatula. As a rule it is not advisable to pour the plaster into molds immediately after mixing, but rather to let it stand quiet for a few moments so that it can thoroughly take up the water. But this resting period must not be too greatly prolonged, so that the plaster has entered upon the setting process, or it will no longer fill out the smaller interstices of the mold.

4. Where, in making a casting that is of very large dimensions, it is necessary to make two or three successive pourings of plaster, the second should be made rather a little stronger than weaker and very carefully stirred, so that it will give off no superfluous water to the first pouring and thereby disturb it in the setting process. In the same manner, the third and fourth installments of plaster must be progressively stronger. The last should be capable only of application by means of the trowel. If in such a case the earlier casting has begun to harden, it is better to await its complete hardening before proceeding to another pouring. We can recognize this condition by the fact that the dry stratum expels the surplus water (sweats).

Plaster that has not been properly burned sets very slowly, but when dried out is uncommonly hard. Dead burned plaster is utterly useless. The smaller the quantity of water used in preparing plaster the harder and more solid will be the plaster cast after hardening. The setting of plaster, when mixed with water, depends on a chemical combination with water. The hardness of the cast gypsum is, however, governed by the observance of the proper temperature in burning, only the portion hardening that was not over burned; the dead burned particles consequently behave like a foreign body; they are mechanically incorporated, but do not contribute in the slightest to the hardness.

In the case of properly burned plaster, the setting occurs very rapidly—in one or two minutes—and is attended with a slight increase in temperature, due to the latent heat given off by the chemically combined water. Special care must be taken in the preparation of the plaster, to avoid any air bubbles, a sufficiently difficult task, especially where the plaster is mixed very thick. A certain means of preventing the occurrence of air bubbles, which can, of course, be practised only in connection with small quantities, is to secure the vessel containing the mixed plaster to the rim of a flywheel, which is then caused to revolve at its highest speed. As a result of the centrifugal force, the heavy plaster forces itself downward, while the lighter air bubbles find their way to the surface in their tendency toward the axis.

The pulverized gypsum, deprived by calcination of the water of crystallization, attains its greatest hardness, as a rule, on the addition of no more water than is required to make it into a stiff paste. For this purpose at least 33 per cent of water is required, of which, however, only 22 per cent, the before mentioned water of crystallization, is taken up. The remaining water evaporates, causing the porosity of the hardened plaster. In small quantities of plaster there is barely time for its use for modeling purposes before it hardens. In the case of larger quantities, where the preparation of the mass requires a longer time, the hardening actually occurs in part during the period of preparation.

According to Abaté, in order to obtain a solid, stone-like mass, in preparing the plaster we should use no more water than the natural gypsum contains and after mixing, seek to attain, by heavy pressure, the closest contiguousness of the molecules, their cohesion being in inverse ratio to their distance apart. According to this, the ordinary method of handling plaster is altogether erroneous and accounts for the unsatisfactory quality of the product. As a rule, we mix the plaster with a far greater proportion of water than is necessary; the quantity used amounts to as much as 200 per cent, or almost eight times as much as the gypsum rock contains. The hardening of the plaster follows immediately and after the superfluous water has evaporated there remains a porous substance that absorbs moisture and exposed to heat and cold alternately, is speedily disintegrated. In order to slake the plaster with the smallest possible quantity of moisture, Abaté uses water in vapor form. He places the burned plaster in a cylinder resembling the receptacle of a coffee roaster, that turns on its axis, and connects the cylinder with a steam boiler. By this means the plaster is caused to absorb in a short time the desired volume of water, which can be determined exactly by weighing. With plaster prepared in this manner, which retains its pulverulent form, the molds are filled and exposed to the action of a powerful hydraulic press. The plaster prepared in this manner is completely compact and hard and assumes a marble-like polish; the process is admirably adapted to the production of solid objects, with the aid of metal molds. The inclosed forms must then be cut apart with fine saws and rejoined together by casting or pressure.

Concerning plaster casting proper, H. G. Mertens offers the following: In making plaster casts, the oiling of the object of which a cast is desired and the mixing of the plaster with water, require especial attention. For the first purpose we require and must choose a non-penetrating, light, perfect-covering fat. For casting, we must not pour the water on the plaster, but scatter the latter as loosely as possible on the water until it has reached the surface, when it must be quickly stirred together. The preparation of the fatty substance is so effected that to a solution of soap in water ordinary lamp oil is added (known in practice as greasing). If the object of which it is desired to obtain a casting is itself of plaster, it will require repeated coating with shellac to prevent the absorption of the oil as far as possible and facilitate the freeing of the model. In order that the desired sharpness of the casting shall not be impaired and that there may be no bubbles or uncoated places, the first coating of plaster must be applied as thin as possible and a little assistance given with a small brush or a pointed instrument in pouring in the remainder. The final portion, more and more paste like, can be applied with a trowel and smoothed off. If we run at first thin and afterward plaster of thicker consistency and then moisten the still warm and almost fully hardened object in the mold with hot water, which it is allowed to absorb, water vapor will form between the casting and the mold which, even without the employment of the oily medium, will allow the casting to be easily detached from the mold. This occurs even spontaneously, accompanied by an audible crackling sound. By observing the method above described the release of the plaster cast is effected, where water or watery solution of common salt, Glauber salt, or other salt solutions are employed. It is often an object, in the case of delicately-formed, sharply-outlined objects, to avoid the use of oil.

Agate buttons (artificial) may be made of a frit, consisting of 33 parts of quartzose sand, 65 parts of bone-earth, and two parts of potash. The frit, burned until it is vitrified, is finely ground, mixed with kaolin, pressed into the form of buttons and kilned. The finished buttons are treated with a transparent glaze, which is fused on.

TELEPHONE DICTATING APPARATUS.

MESSRS. KELLEY M. TURNER and William F. H. Germer, of New York city and Hoboken, N. J., respectively, have been granted a United States patent (No. 843,186) on a telephone dictating machine which they term a "dictograph," being a telephonic system or apparatus by which a person—for example, the manager of an office—may dictate letters to any one of his corps of stenographers without requiring them to leave their places at their own desks.

"By the ordinary telephone system," say the inventors, "a central operator is able to talk to any selected persons on connecting lines, but the conditions are not at all the same as if the communicating persons were in the same room and directly speaking to one another. The first point of difference is that the speaker has to direct the sound closely into the telephone transmitter. For best effects the speaker is about two inches from the mouthpiece, so that his action resembles talking into a speaking tube more than the act of general conversation in a room. The second point is that the person at the receiving end has to listen with the receiver at his ear. The third point of difference is that both cannot very well talk at once, since the sound goes over a single pair of line wires. Also the receivers at each station are in circuit with both transmitters, so that either receiver gets not only the sound transmitted from the other station, but sound at the transmitting station.

"By our invention we make use of what we shall term a 'loud earpiece,' or, in other words, a 'loud-speaking telephone receiver.' This is in itself not a novel feature, since loud-speaking telephone receivers are well known; but we also employ a special form of transmitter which obviates the necessity of the operator standing anywhere near the mouthpiece. In addition to this we so arrange the circuits as to avoid delivery of the sound spoken at each end into the receiving instrument at that end of the line.

"The invention also has in view many incidental features—for example, the connection of any individual stenographer and certain indicating means to indicate when the stenographer is ready and means for conveniently putting into circuit either the loud earpiece or an ordinary receiver, a special calling system, a switch in constant reach of the operator's or manager's fingers by which the ordinary receiver or the loud earpiece may be thrown into action, and many other features which we have worked out so as to obtain all the conditions of a manager dictating to a stenographer directly at his desk, while, in fact, the stenographer is at a remote point."

Referring to the drawings, (1) in Fig. 1 indicates the manager's instrument, which is convenient in the form of a rectangular box or casing or any sort of adjustable arm attached to the manager's desk. This instrument has on its face an acousticon transmitter (2) and a loud earpiece (3), which for certain practical reasons is separated quite widely from the transmitter. A specially constructed telephone receiver (4) is hung upon a permanent or fixed hook. Annunciator drops (6) may be of the ordinary sort employed in telephone switchboards, and (7) indicates apertures for an ordinary plug or jack by which certain connections are made. (8) is an ordinary push-button, and (9) a switch, which serves certain functions hereinafter described; (9') designates an ordinary call-bell.

Referring now more particularly to Fig. 2, the various devices above mentioned and forming part of the manager's instrument, together with the circuits and connections therefor, are all illustrated beneath the dotted line (*AA*). Above the line are indicated three branch lines, which correspond to separate stenographer's instruments. The stenographer's instrument includes an acousticon transmitter (10), adapted to receive spoken sounds at any reasonable distance therefrom, and an ordinary telephone receiver (11); (12) indicates an ordinary telephone hook by which the receiver is hung up, and (13) indicates the usual call-bells; (14) denotes a push-button or switch conveniently disposed at each stenographer's instrument.

For the purpose of supplying the necessary current, a number of batteries (15), (16), and (17) may be used, and which are conveniently situated at the manager's end of the line, about or within his desk or about his office. As will be seen from the diagram of circuits in Fig. 2, each annunciator drop (6) is adapted to close a special circuit at the points (18) whenever an annunciator drop falls to expose the number beneath. In practice this connection is made by a lever or blade at the point (19), Fig. 1, although the connection may be made to occur in any way so as to be completed whenever the annunciator drop falls.

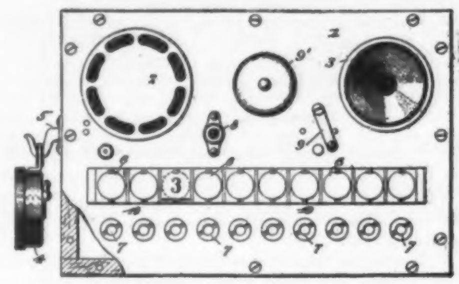


FIG. 1.—FRONT VIEW OF TELEPHONE DICTATING APPARATUS.

The diagram of circuits, Fig. 2, shows the apparatus in its normal or passive condition, when no one is talking. Suppose the manager wishes to dictate a letter to the stenographer at station No. 3. Under these circumstances he takes the plug (7') and inserts it in the aperture (7) of station No. 3. He then presses the push button (8), completing the following circuits: From battery (15) at station No. 3, downward through wire (m'), spring contacts (m^2), with the wires (m^3) (m^4), push-button (8) (depressed), wire (m^5), connection (m^6), contact (m^7), wire (m^8), stenographer's call-bell (13), hook (12), wire (m^9), back to battery. Thus the call-bell of station No. 3 rings, and the stenographer takes her receiver off the hook and presses the button (14). This completes the following circuit: From button (14), through wire (n'), battery (17), wire (n^2), annunciator (6), which is the third one on the manager's instrument, causes it to drop into the dotted position shown, wires (n^3) and (n^4), back to the push-button (14).

In this way the manager learns that stenographer at station No. 3 has correctly received his signal and is ready to take his dictation. He accordingly proceeds with the dictation in an ordinary voice and without any necessity of placing his lips close to the transmitter. This is on account of the fact that an acousticon transmitter is used, so that the manager may dictate at his desk or in any convenient manner, exactly as suits his habit of dictation when a stenographer is present in the room. The talking circuit under these circumstances is completed as follows: From acousticon transmitter (2) through wires (o') (o^2), contact (o^3), wire (n^3), battery (17), wire (n'), contact (o^4) (now completed), stenographer's receiver (11), wire (m^8), contact (m^7), and wire (m^5), back of the acousticon transmitter (2). This is, therefore, a closed circuit, including the transmitter, a battery, and the stenographer's receiver, as required.

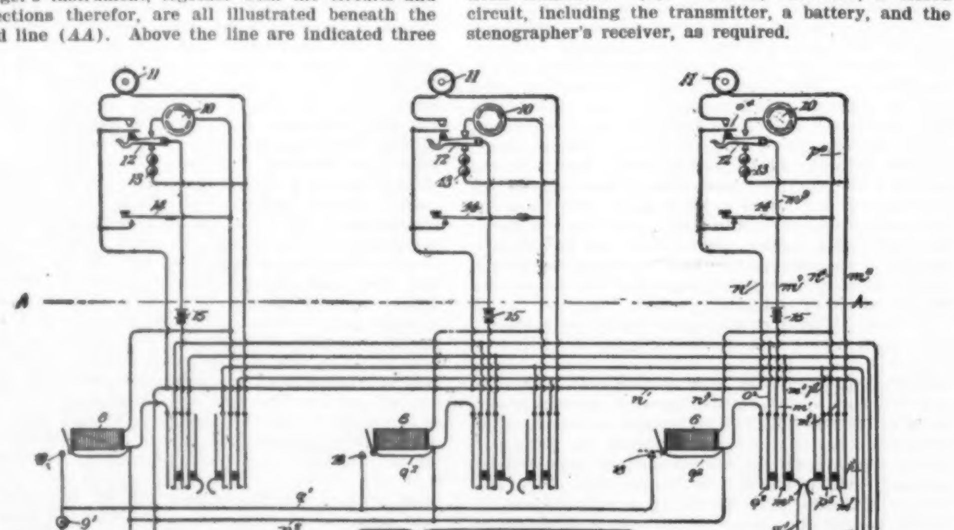


FIG. 2.—DIAGRAM OF CIRCUITS OF THE DICTOGRAPH.

The dictation proceeds in the usual way, and under these circumstances the stenographer will frequently desire to ask about the nature or spelling of a word or name, or ask to have a sentence repeated or further data given, and under these circumstances it is merely necessary for her to remark the facts in an ordinary tone, without placing her lips to the transmitter or in any way removing her attention from the notebook before her.

The stenographer's remark is received in the acousticon transmitter (10) at her station and is received in the loud earpiece at the manager's instrument by an entirely separate circuit from the manager's talking circuit. This circuit is as follows: From the stenographer's acousticon transmitter (10), through hook (12), wire (m^9), battery (15), wire (m'), connection (m^3), and wires (m^2) and (m'), switch blade (23), wire (p'), loud earpiece (3), wires (p^2), (p^3), and (p^4), connection (p^5), wire (n^4), connection (p^6), back to the acousticon transmitter (10).

It will be observed that in this circuit a different set of line wires is traversed than in the case of the manager's talking circuit. In this way there is no interference of the messages and no confusion. It will also be seen that the manager's talking circuit does not include his own receiver, nor does the stenographer's talking circuit include her receiver. This also obviates the confusion which would otherwise occur on account of the loud transmitters and loud earpieces, which are, of course, an essential with a dictograph.

While the instrument is particularly designed for the purpose of dictating to the corps of stenographers, it is also adapted for communication with various heads of departments about the building in the same way as an ordinary telephone.—Western Electrician.

WHAT IS A WATT?*

By GEORGE SHERWOOD HODGINS.

THE word "watt" is an electrical term, and stands for a certain unit of power. Work, as distinguished from power, is defined as pressure acting through distance and is usually expressed in foot-pounds, as the foot is a convenient unit of distance, and a pound is a common standard of weight or pressure. When the word power is used it signifies a rate at which work is done, as work being carried on so that a certain quantity of it is performed in a stated time.

James Watt, the Scottish inventor and engineer, was the man to whom we owe the idea of a horse-power, and when the electric unit involving the idea of work came to be formulated, the name of Watt was chosen to indicate this unit, just as that of Volta has given us the term volt, and Faraday the farad.

Watt considered that taking the average, a London dray horse was capable of doing the work of lifting 33,000 pounds through one foot of distance in one minute of time, against gravity. The introduction of this time limit, the minute, gave the unit of power or the rate of performing work. This or its equivalent has ever since been called a horse-power. It is not probable that a horse would be able to perform work continuously at this rate for any considerable period of time, but for ordinary purposes the horse-power is a convenient unit. It is, in fact, work performed at the horse's rate of doing work which we refer to when we speak of a horse-power and that is equivalent to 33,000 foot-pounds per minute, or to the raising of 550 pounds one foot high in one second, and if repeated continuously for one hour it is spoken of as a horse-power-hour.

The electrical unit called the watt is capable of being represented in terms of the horse-power, and in that form it is perhaps more intelligible to those who are familiar with mechanical, rather than with electrical expressions. The electrical watt is the product of volts multiplied by amperes, where the volt is the unit of electrical pressure and the ampere is the unit measuring the intensity of an electric current. The ampere is represented as the unvarying electric current which when passing through a solution of nitrate of silver in water deposits silver at the rate of 0.001117 of a gramme per second, or a current which in each second deposits by electroplating 0.00033 gramme of metallic copper, is said to be one ampere intensity.

The ampere, therefore, includes the conception of rate of doing something, and as the watt is the mathematical product of volts by amperes, it necessarily includes the idea of rate, though not that of absolute quantity. The chemical separation involved in the deposition of pure metal from a solution in a given time becomes a measure of intensity of activity, but is not regarded as the performance of work, in the sense of pressure acting through distance.

The expression "watt per second," though correct, is not used for the same reason that the expression "horse-power per minute" is not used. The conception of horse-power involves the idea of rate, and so also does the watt, but watt-second is what is really meant by the general use of the term watt.

Careful experiments have demonstrated that 746 watts per second are equal to 550 foot-pounds per second, or to state the equation in its usual form, 746 watts equal one horse-power. The form in which electrical power is generally sold is computed on the basis of kilowatt-hours. The prefix kilo comes from the Greek *chilioi*, one thousand. A kilowatt, written also k.w., is therefore 1,000 watts. The kilowatt-hour is the performance of work at such a rate that 1,000 watts per second shall be delivered continuously for one hour.

The kilowatt-hour has a special interest for the man who has his office or house lighted by electric lamps, because the kilowatt-hour is the unit upon which the power and light companies base their charges. The kilowatt-hour is stated on the accounts rendered, to be approximately equivalent to the steady use, for one hour, of 20 standard incandescent lamps, each one

* Railway and Locomotive Engineering.

giving about as much light as 16 standard sperm candles. The kilowatt-hour is also roughly speaking, equal to the use, for one hour, of two arc lamps such as are employed in street lighting.

The mechanical energy necessarily expended for the production of light in 20 incandescent lamps for one hour, is about equal to 1.34 horse-power, and the energy required to keep up the glow in one of these lamps for an hour must therefore be the twentieth part of the number just given or 0.067 of one horse-power. The expenditure of this amount of energy may be more readily comprehended if stated in terms of what we may here call man-power instead of that of the horse.

In former days the power required to drive church tower clocks was obtained by the gradual falling of a heavy weight, attached to a rope which was wound round a drum. This arrangement was similar to the mechanism of a grandfather's clock. When the church clock had run down, a man wound it up by attaching a crank-handle to the axle of the drum, and revolving it until the weight was drawn up to the required height inside the tower. If the same style of mechanism could be applied to the production of light in an incandescent electric lamp, a weight of one pound would have to be raised 36.85 feet in each second in order to maintain the glow, for one hour in one of the 16-candle power bulbs with which we are all familiar.

In every machine there is a certain amount of loss due to internal friction, so that we never get out of a machine, as work, the full amount of energy put into it. This is true of all the transformations of energy used in the arts. In a recent lecture delivered by Sir James Dewar before the Royal Institute in London, he stated that out of the total amount of energy required for one glow lamp, only 3 per cent was actually transformed into light, and that 97 per cent was expended in a non-luminous form. This statement is not so surprising to those who have reason to know that in the best stationary steam engine practice, it is probable that not more than 15 per cent of the total energy developed in the burning of the fuel is ever transformed into useful work while in the case of a locomotive probably from 6 to 10 per cent is all that is available. In a general analysis of electric light radiations, many years ago, Tyndall found that the invisible emission from this source of light was eight times that of the visible.

Taking Prof. Dewar's figures and applying them to the case before us, it is evident that out of the total energy stored up when the hypothetical one pound weight was raised in the clock tower for the production of light, and steadily liberated during one hour by the gradual fall of one pound through a distance of 36.85 feet in every second, that a distance as great as 35¾ feet per second would be traversed by the descending weight in the production of heat and in overcoming internal resistances. Further, that all the actual energy which the lamp was able to radiate as light, could be produced by the downward movement of the one pound weight for a distance of only 1 1-10 foot in each second. No light, however, would appear unless the whole distance of 36.85 feet had been traversed by the weight. In this, however, the incandescent lamp is superior to the 16 candle which it supplants, for in their case the luminous energy produced by the burning of each one is only 2 per cent, while the non-luminous energy is 98 per cent of the total amount liberated by the consumption of the melted fuel, by the tiny flame.

AN AIR-PROPELLER TESTING DEVICE.*

By A. M. HERRING.

AMONG flying machine experimenters there is about as great a diversity of opinion in regard to the design of screw propellers as there is a dearth of actual knowledge of their efficiencies.

Perhaps not one experimenter in a thousand could answer any of these twelve questions correctly:

1. At what speed should a propeller be revolved to give a certain thrust?
2. What combination of pitch and number of turns per minute would make it produce a given thrust with the least power?
3. Is it better to use a fine pitch and revolve the screw fast?
4. Is it better to use a coarse pitch and revolve the screw slower?
5. Is it better to use wide blades or thin ones?
6. Should the blades have a uniform or an increasing pitch?
7. Is it better to use two blades?
8. Three blades?
9. Four blades or more?
10. Given two screws exactly alike, but one two or three times the diameter of the other, how much more thrust should the larger give than the smaller when revolved at the same speed?
11. How much more power does it take to get a given number of pounds thrust while traveling at 20 or 30 or 40 miles an hour than it does to give the same thrust while standing still?
12. What percentage of the power used is due to skin friction?

There are a dozen other points a flying-machine inventor should know definitely before he can attack the problem intelligently, since errors in the screw design may easily mean the need of an engine of from 30 to 100 per cent more power than would otherwise be necessary.

To get reliable data on these points, the apparatus herewith illustrated was designed, and on it some ten or more different sizes and types of screws have up to the present been tested, both in still air and in a powerful blast of a known velocity.

Referring to the drawings:

M represents a variable-speed electric motor of about 5 horse-power. The motor is rigidly mounted on a table, and by means of resistances and a controlling handle may be kept running at any desired speed between about 700 and 1,500 revolutions a minute at will.

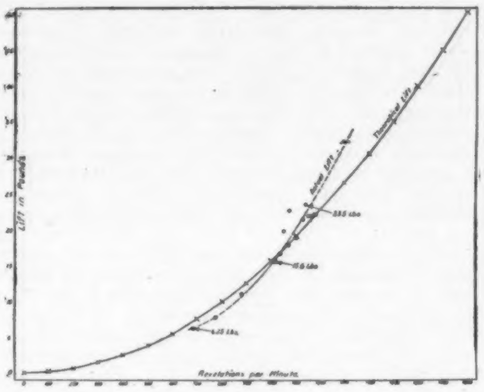


DIAGRAM SHOWING THRUST OF AN AIR SCREW AT DIFFERENT SPEEDS.

The propeller, *V*, to be tested is mounted on a shaft, *T*, on which is mounted a pulley wheel, *P*.

This shaft, *T*, runs in ball bearings, *W* and *U*, and is held in place in the room by six wires, *H'*, *H''*, etc. These suspending wires have inserted in them turnbuckles for the purpose of adjustment, and very stiff springs for taking up vibration at high speed.

An endless belt connects the motor pulley, *R*, with the pulley, *P*, on the propeller shaft. This belt is made to pass under the ball-bearing pulleys, *N* and *O*.

These pulleys have suspended upon them the equal weights, *C* and *D*, for the purpose of keeping the belt taut.

In testing, the speed at which a propeller is turning is measured at *W*, where the shaft projects through the bearing.

The amount of power (foot-pounds per minute consumed in driving the screw) is the pull on the belt multiplied by its speed. Or, to be more exact, it is the pull on the belt multiplied by the number of turns of the pulley, *P*, per minute multiplied by the circumference of this pulley in feet.

The circumference of *P* can be directly measured, and the pull on the belt is always exactly half the reading of the scale, *B*.

The thrust of the screw is measured directly by means of the scale, *A*, which is connected by a wire with the bearing, *U*.

A stop, *S*, prevents the shaft, *T*, from moving back beyond a certain point. An electric contact, *E*, and lamp, *L*, show when the propeller pulls enough to move the bearing away from *S*.

The turnbuckle, *G*, is used for adjusting the force with which the propeller axle is held against the stop, *S*, and which force must be overcome before the lamp, *L*, glows. This force—the actual thrust of the screw—is measured directly on the scale *A*.

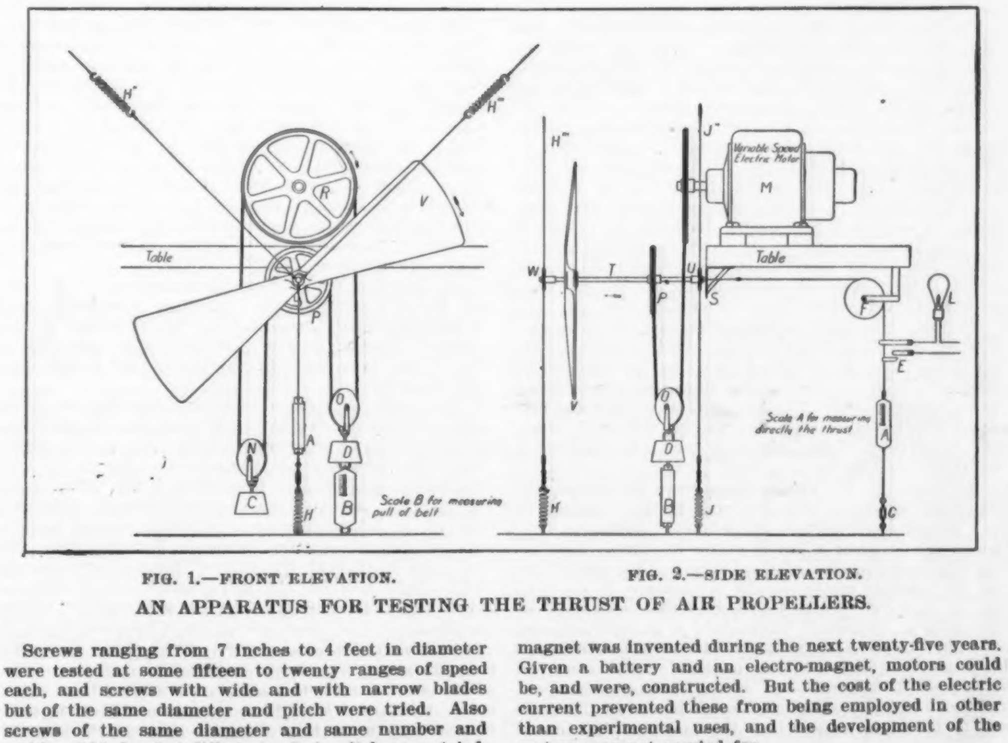


FIG. 1.—FRONT ELEVATION. FIG. 2.—SIDE ELEVATION.

AN APPARATUS FOR TESTING THE THRUST OF AIR PROPELLERS.

Screws ranging from 7 inches to 4 feet in diameter were tested at some fifteen to twenty ranges of speed each, and screws with wide and with narrow blades but of the same diameter and pitch were tried. Also screws of the same diameter and same number and widths of blades, but differing only in pitch, were tried. A screw of 40 inches diameter and having no pitch was also tested at many speeds, to determine the power used in skin friction. As the apparatus was built throughout with great care, and ball bearings were used everywhere, the friction of the apparatus itself was found to be surprisingly small—so small, in fact, that even in the experiment on skin friction, the forces could be measured with accuracy. Incidentally, the reduction of the thrusts of the various screws caused by the wind pressure against the pulley, *P*, was arrived at with considerable accuracy by substituting pulleys of different diameter, and noting the change in thrust of the screws when running at the same speed.

To get an idea of the relative values of different designs of screws under conditions of actual practice, a second motor (not shown in the drawings) was mounted in front of *W*. A propeller was directly mounted on the shaft of this second motor, and made to furnish a blast in which the screw being tested worked. As the second motor could also be driven at any desired speed, and the blast from it accurately measured, the screws could be and were tested under conditions which closely approached those to be expected in practice, where the flying machine moves through the air in flight.

The results, embracing some nine hundred or more readings, have not yet been fully tabulated and analyzed, but enough has been done to see that differences in design may easily mean great saving or waste of power.

The third figure herewith represents some of the results obtained with a moderately small screw—40 inches in diameter. The dotted line represents the actual pressures and speeds. The circular dots outside of this line are observations of pressures and speeds taken when a person stood near and affected the flow of air to or from the propeller. The heavy curved line shows the theoretical increase of thrust of an air propeller with a given increase of speed. By placing an obstruction in front of the propeller when it was revolving in still air, more thrust was obtained than was theoretically possible, as can be seen by the several plots at the left of the theoretical line. Blocking the flow of air at the side of the propeller had a tendency to diminish the thrust.

* This article was prepared by Mr. Herring for a book to be published shortly by the Aero Club of America.

A QUARTER CENTURY'S PROGRESS IN THE APPLICATIONS OF ELECTRICITY.*

ELECTRICAL phenomena, in some form or other, have been known for ages, but they merely called forth comment from the early philosophers. In the last half of the eighteenth century frictional electricity began to attract the attention of students of natural philosophy of those days, but it is not probable that continued investigation of this phase of electrical action would have produced results of much every-day value. In fact, it is only very recently that static electricity may be credited with practical applications.

But an accident noticed by Galvani started research in another direction, and through the efforts of Volta and others, produced the primary battery, our first source of electricity in quantity. This was a mighty step forward, because now it was possible to obtain electrical energy in large quantities. But there was one defect fatal to the application of the new power in industry: The power thus obtained was costly.

This defect, however, in no way interfered with the scientific study of electrical phenomena. There were, of course, in those days no mechanisms capable of utilizing this power, but these were forthcoming before very long. The galvanic battery was devised in the last year of the eighteenth century. The magnetic effect of galvanic currents was noticed, and the electro-magnet was invented during the next twenty-five years. Given a battery and an electro-magnet, motors could be, and were, constructed. But the cost of the electric current prevented these from being employed in other than experimental uses, and the development of the motors was not carried far.

There was need then for the next step in advance, a

* From the Electrical Review (New York).

step which would give us a cheap means of obtaining electrical energy. Whether this need was distinctly felt cannot be said, but there were not wanting inquiring minds who asked the question: If an electrical current produces motion, may not this action be reversed; is there not some way of moving a device so that a current will be started? It was Faraday who answered this question, after a dozen years of constant effort. He found a method; he discovered that a current could be started by moving a body in a magnetic field, conditions, of course, being such that the current could flow. This was in 1832. It constituted another of the great stepping stones, but there still remained the next: Means must be found for putting Faraday's discovery into practical form. This was not forthcoming until 1868, but during this period progress was being made in other directions. The telegraph was invented and progress made in other directions, so that when Gramme devised his dynamo its significance was immediately recognized, and thereafter progress went on at a vastly greater rate. The fact that this mechanism was reversible, and could be used as a motor, was soon discovered, and thus all the essentials for applying the new power to every-day work had been brought forth. It must be recalled also that Faraday discovered the principle of magnetic induction, which laid the basis for alternating-current transformation. Previous to Gramme's invention magnetic dynamos had been in use, but they had not led to much advance in the art of producing electrical energy.

Thus, in the early seventies of the last century, the principles of electrical application had been evolved, and there only remained the working out of systems, the improvement of devices so as to make them practical, and the devising of methods to reduce the cost of the new power, however used, to a point where it was feasible to introduce it.

By this time the telegraph was well established both on land and under water. The next steps were the invention of the speaking telephone by Bell, and the devising of a system of arc lighting by Brush. These were followed by the incandescent lighting system of Edison. These three applications had been worked out and were just gaining a foothold when the first issue of the Electrical Review appeared. The telephone of those days used the Bell receiver and a battery transmitter; the switchboard was in the first stages of development; practically all circuits used the ground return, and all wires were overhead. There were about 180,000 instruments in use in this country, an exceedingly satisfactory showing for the first six years of growth. Various systems of arc lighting had been more or less perfected. All employed special dynamos of peculiar design and an open arc lamp. This system of lighting was being introduced for street illumination. Various features of the incandescent system had been worked out after much labor, and the first central station was being constructed. In fact, it was on September 4, 1882, that the Pearl Street station of the Edison system in New York city was opened. Thus three important applications had been started through the tireless efforts of inventors who seemed proof against all disappointments and discouragements. Their foresight was good; they had perhaps played the most important part in opening what will certainly be known as the electrical era. Yet they could not have dreamed how wide the influence of their work would be; how it would be felt throughout the entire civilized world and would leave untouched hardly a single line of human endeavor. At that time there were also others who believed that the new power could be applied in other ways. And yet the electric motor was a toy.

The next year, 1883, is significant, because it was then that the first promising attempt was made to apply the motor to railway work. Siemens Brothers, of Germany, during this year opened a small third-rail system at the Giants' Causeway, Ireland, and at the Chicago Exposition an electric locomotive was shown by Edison and Field. Leo Daft built a small electric line at Saratoga Springs, N. Y. These were the first experiments with the electrical railway on a practical scale, but it was not until some years later that a system had been sufficiently developed to enable it to enter into competition with other methods of traction. The year is nevertheless significant as marking an important phase of development, for it was then that the system was brought to public notice.

The next year, 1884, witnessed further efforts to perfect an electric railway system. The Siemens Brothers again took an important step by introducing an electric system on a horse-car line connecting Berlin and Charlottenburg. The first conduit system was laid down in Cleveland, Ohio, by Bentley & Knight, while the forerunner of the trolley system was constructed by Henry at Kansas City, Mo.

At this time the new systems were attracting considerable attention, and this was much increased by the electrical exposition opened in Philadelphia, Pa., under the auspices of the Franklin Institute. This not only opened the eyes of the public to the possibilities of the electric motor, to the importance of the telephone and the electric-lighting industries, but it resulted in an important movement. A national congress of electricians had been authorized by the federal government, and the bringing together of men from all parts of the country who were interested in applications of electricity and the study of electrical science resulted in the founding of the American Institute of Electrical Engineers, a society which has played an important part in the history of the electrical industry. The year 1885 also witnessed the founding of another influential electrical society—the National Electric Light Association.

During these years the electric lighting industry, as well as the telephone, was making much advance, but it was mostly in the perfecting of the systems, and no great event stands out. The electric railway, however, was still in the experimental stage, so that undertakings, though really small, were of comparative importance. It was during 1885 that the first commercial electric railway was started in this country—a short line between Baltimore, Md., and Hampton. The system was installed by Daft. It employed a central third rail, and the cars were drawn by small locomotives which replaced horses. It operated with some success for over a year, but finally was abandoned, as it had fallen into disrepair. During the same year an underrunning trolley was tried on a short road at Toronto, Ontario, and Frank J. Sprague read a paper before the American Institute of Electrical Engineers discussing a proposed electrical equipment for the elevated roads in New York city. During 1886 Sprague carried out experiments on the elevated, placing his motors on the car trucks; but it is the year 1887 which marks the closing of the experimental era of the electric railway and the opening of the actual introduction of the system, for it was then that Sprague made a success of an overhead trolley system installed at Richmond, Va. The undertaking was large, as there were fourteen miles of track. The system adopted was essentially that known as the overhead trolley. From this time on the most striking feature of electric railway development has been its rapid and wide introduction. The various parts of the equipment, of course, have undergone much improvement, but it was not until some years later that any radical change was proposed. It is worthy of note, however, that in 1888 Daft operated the Ninth Avenue elevated line in New York city with the first large electric locomotive. His motor was capable of drawing six cars at a speed of forty miles an hour.

In the electric lighting industry several significant events had occurred. In 1885 the storage battery was for the first time added to an electric-lighting plant, this being at Phillipsburg, Pa. Of late years the storage battery has become an important part of the station equipment. During the same year the Westinghouse Electric and Manufacturing Company was founded as an outgrowth of the old United States Electric Light Company, and has since grown to be one of the great electrical companies of the world. At this time also the same company introduced the alternating-current lighting system devised by William Stanley, and thus started the rivalry between the two systems—alternating and direct—which has not yet ended.

About this time the rapid growth of the telephone systems required so many wires overhead that the necessity for placing them underground was recognized, and the work was in progress.

The next few years were years of great commercial development, but a few important developments stand out. In 1888 Nikola Tesla described his polyphase system before the American Institute of Electrical Engineers, thus giving the alternating system a means of competing with the direct-current electric motor, which was somewhat slowly coming into use for small power purposes. During the following year an important step in the utilization of water power for producing electrical energy was taken when a commission was organized to study the problem presented by Niagara Falls. Water power had previously been used for driving dynamos, notably for the Giants' Causeway Railway; but now it was just being realized that cheap electric power was destined to be a valuable boon to industry. Particularly would it bring to cities a much-needed supply. Already the effects of the electric railway upon city life were being felt, and the importance of providing better lighting, both in the homes and on streets, was well realized. Not only was greater comfort to the citizens thus secured, but work was made easier in innumerable ways, and the streets were made safer. There can be no doubt that the electric lighting of streets, as well as the electric railway, have been powerful factors for improving thoroughfares; and, as a result of this, attention was given to cleanliness and sanitary conditions.

In 1889 the Thomson-Houston Company took over the Brush Company, thus beginning a series of consolidations finally resulting in the formation of the General Electric Company in 1892, the influence of which has been wide in developing and introducing electrical methods.

The study of Niagara Falls as a possible source of power marks the beginnings of electrical transmission of power. To be successful, a high potential was essential. The first serious attempt was made in 1891, in California, the pressure then being 10,000 volts. Lack of financial support rendered the attempt a failure, but in the following year a polyphase system was installed for transmitting power to Pomona, Cal., and the year after, 1893, the contract for the first Niagara Falls plant was let, the plans being upon a scale at that time stupendous. The development of 50,000 horse-power was contemplated in generators rated at 5,000 horse-power each, figures which inspired considerable awe in those most familiar with electrical work. This plant was actually put in service in 1895. Power was transmitted to Buffalo, N. Y., and, contrary to expectations, the establishment of metallurgical and electro-chemical industries in the immediate vicinity of the power house created a local demand of much greater importance than that of Buffalo. The possibility of this had been in mind, but it had at first been thought that the transmission of power would be the most important feature. Thus another great branch of the electrical industry had been fairly launched.

In the meantime the telephone, electric lighting, and railway industries had witnessed significant developments. Bell's fundamental patent expired in 1893, and during the preceding year independent telephone companies had been organized in expectation of this event. During 1892 also the long-distance system had been rapidly developed, so that then communication had been established between Chicago and Boston.

The most important event in electric lighting was the bringing out of the long-burning inclosed arc lamp in 1892.

In 1893 the World's Columbian Exposition was opened at Chicago, and the electrical features of this exposition were noteworthy in many respects. The electric-lighting system offered opportunities for decorative illumination which were utilized with wonderful effect, and the electric intramural railway was notable for the size of its equipment. In the early years of development the electrical engineer was hampered somewhat to find a suitable prime mover for his generators. The latter were necessarily comparatively small, and ran at a high speed. Belt driving was necessary, and the demand for well-governed, high-speed engines led to a remarkable development in this branch of mechanical engineering. There were, it is true, exceptions to this method of driving, but throughout the eighties that generally adopted was by belts connected to a large flywheel or through a countershaft. At the time of the exposition at Chicago the increasing size of the generators made it desirable to do away with belting and drive them directly from the engine. Since then this tendency has largely prevailed, so that except for special cases or very small dynamos, the direct drive is almost universal.

An event of much importance which took place during the exposition was the holding of the International Electrical Congress. In this electrical engineers from all parts of the world came together to discuss matters of importance and to hear papers upon new developments. The first steps toward adopting an international system of units were then taken.

The electrical railway was now becoming the standard method of propelling street cars in cities. It had practically but one competitor—the cable—and was rapidly demonstrating its superiority over the latter. In 1894 two important steps were taken. One was the construction in Washington, D. C., of a complete conduit system, the conductors being placed underground and no overhead wires being allowed. This system was introduced later into New York city. So far as the mere moving of the cars is concerned, it presents no advantages; but when the importance of the system warrants the expense, it complies with that desirable condition of avoiding any overhead wires within the city proper.

During this year also the first system of heavy traction was installed on a section of the Baltimore & Ohio Railroad, through the new tunnel which that road had driven under the city of Baltimore. Due to the length of this tunnel and the difficulty of securing ventilation on account of the city's requirements, large electric locomotives weighing ninety-six tons apiece were introduced for hauling the steam trains through the tunnel. This system is still in operation, although there have been some modifications in the type of locomotive employed and in the method of collecting current.

The electric railroads were now reaching from the cities out into the country. They were connecting the neighboring villages with the city, and these were the beginnings of the interurban roads, which have since spread so rapidly. At this time also the system had turned the human tide from the cities toward the country; it had made it possible to live some distance from the place of working and not waste too much time in traveling to and fro. The suburban sections of all large towns began to grow rapidly. Cities which before had been of secondary importance now became important as places of residence, and the necessity for living in apartment houses disappeared, except in some less fortunately located towns.

During this year, 1894, a discovery was made which rapidly became of incalculable value. It had been noticed by Röntgen that an electrical discharge through an exhausted tube set up some form of radiation which penetrated bodies opaque to visible rays. The ease of penetration varied with different substances, flesh being more transparent than bone. These rays, called by the discoverer "X-rays," also brought about the chemical action necessary for photographing. Thus it became possible to examine bones and other bodies within living tissue without injury to the latter. The benefit to surgery can hardly be overestimated. The application of this effect has developed marvelously since the discovery, and the X-ray equipment is now one of the most essential appliances for all modern surgery.

During this year the first use of electrical discharges through exhausted tubes as a means of illumination was made on a large scale. This was the result of the labors of D. McFarlane Moore. To-day his system, in its improved form, is finding wide use in many locations where its peculiar features are advantageous.

During these years of marked activity in the telephone, electric lighting and electric railway industries the telegraph had forged ahead steadily and on a solid basis. Compared with the telephone the development was slow, but this was due to the marvelous rate at which the latter grew. There had been no great

changes from the systems well developed previously. There had been devised several methods of machine telegraphy, but none had come into use; in fact, up to the present time, while there are a number of beautiful systems, the old and simple methods are still employed. There had been one change—the introduction by Field, in 1879, of the dynamo in place of the battery, which effected a considerable economy in the cost of power and saved much space in the companies' buildings. But the system was essentially that which had been used for about twenty years. In 1896, however, there came a suggestion of a new system. Late in the eighties Hertz, following Clerk Maxwell's analytical arguments, had shown experimentally the existence of electrical waves in the ether. The possibility of utilizing these for communicating at a distance, without intervening wires, had been suggested; but it remained for William Marconi to devise a system which pointed the way to the solution of this problem. His system, consisting of an antenna in which oscillations were set up by means of an electrical discharge across an air-gap, and a receiving antenna associated with a device sensitive to the electrical disturbances which the waves set up in it, is essentially the system in use to-day, although numerous inventions have vastly improved the methods of producing oscillations and increased the sensitiveness of the receiver. That used by Marconi was the so-called coherer, a device discovered by Branly. Marconi succeeded in transmitting signals across short distances. His results drew many other workers into this field, and the progress since then has been rapid. Each succeeding year has seen greater distances covered, until, in 1901, Marconi himself first transmitted a signal across the Atlantic Ocean. The following year communication was maintained with the steamship "Philadelphia" until she was 1,500 miles away from the sending station at Poldhu, Cornwall, and later in the year communication was established between Poldhu and Glace Bay, Nova Scotia. Since then communication across the ocean has been established by others also, but the system has not yet been put into actual service. This method of communication is one of the great achievements initiated during the last part of the nineteenth century.

During 1902 the first cable across the Pacific was laid, thus completely encircling the globe, and the first message was sent around the world. During this year also the first section of the American Pacific cable was laid to Honolulu. This cable was completed during the following year.

Since the starting of independent telephone companies in 1892 this movement spread rapidly. In 1896 the independent companies formed an association to protect their interests. By this time the telephone system had been greatly improved. The introduction of paper-insulated cables had cheapened the construction of underground lines, and the introduction of the central energy system, in which a storage battery placed at the central exchange provides all the energy required for conversation and for manipulating the auxiliary devices, wrought a great improvement. The inconvenient and expensive primary batteries at each subscriber's instrument were done away with, and a marked economy effected in the time required to complete connections.

The underground system, although a marked improvement for special purposes, was of limited application, on account of the static capacity of the cables. Attempts had been made to overcome this by means of neutralizing inductances, but in 1900 Dr. M. I. Pupin brought out a system which made it possible to determine where and how to use these coils. The system was tried both in this country and abroad, and was found to effect a very material improvement in transmission over cables, and thus made possible a considerable increase in the length of cable over which conversation may be carried on.

In another field of telephone development much effort was being expended at this time, but no commercial application had been made. This was the perfecting of an automatic telephone system which would do away with the operators at the exchanges. In 1902 an automatic exchange was introduced in Chicago, and in the following year in Dayton, Ohio; Grand Rapids, Mich.; Lincoln, Neb., and elsewhere. While, compared with the manual system, but little progress has been made, it must be remembered that it requires some time to perfect a system so revolutionary in character, and much opposition has been encountered from the advocates of the older method. During the last year or two this system has attracted more attention.

By this time the telephone had spread everywhere. It had reached out from the cities to the country, and was to be found wherever men work; it had brought about almost revolutionary changes in business methods. The output of the individual had been multiplied several times, and armies of messengers had been turned to productive work.

From time to time the possibilities of wireless telephony have received attention, but only during the past year has any real progress been made. The difficulties are very great, but they do not seem to be insurmountable.

Electric lighting systems had grown until they no longer suffered any comparison with gas. The method of generation and of distribution left little to be desired, and the lamps themselves, so far as effects were considered, were highly satisfactory. There was, however, one great drawback: The efficiencies of the lamps were shamefully low. This is by comparison with other electrical developments, and not with other methods of illumination, to which they are far superior. But it was being realized that something must be done to increase the amount of light obtained from a given amount of electrical energy. The first step was made by Walther Nernst, who brought out, in 1898, the lamp known by his name. A radical departure was made in this, as the glowing body was not normally a conductor of electricity, and only became so when heated. This was a disadvantage, but the white character of the light, as well as its high efficiency, have made it an important factor in electric lighting. The lamp was brought out in commercial form in this country in 1901. In 1899 the inclosed arc lamp was adapted to alternating currents, and the city of Buffalo was lighted entirely from power developed at Niagara Falls, a noteworthy feature being the use of aluminium wire as conductors.

But the fight for improved lamps still went on, and efforts were made to utilize the increase in efficiency obtained by adding certain mineral salts to the carbons of the electric arc. This produces a luminous flame, in contrast with the plain carbon arc, which produces light merely by raising the tips of the electrodes to incandescence. In 1902 this type of lamp was taken in hand, but it was several years before it emerged from the laboratory and appeared upon the street. In 1903 another solution of the lamp problem was offered by Peter Cooper Hewitt in his mercury vapor lamp, which has a high efficiency, though a peculiar color. In the following year the magnetite arc was brought out, a variation of the flame arc, through using metal electrodes instead of carbon.

So far, with the exception of the Nernst lamp, all improvements had been limited in the arc lamp, although as a transformer of energy it was much superior to the incandescent lamp, but now a great stride was taken when the tantalum filament was brought out by H. Von Bolton and Feuerlein. In this a highly infusible metal replaced the carbon filament and gave an efficiency much better than that of the latter. Other inventors had previously attempted to improve the incandescent lamp by coating the filament with various materials or by replacing it—notably the osmium lamp—but for various reasons these never became of much importance. The tantalum lamp was, however, the first of a number of improvements, so that there are to-day several types of incandescent lamps far better than the standard carbon lamp. The introduction of these lamps is just taking place, and the effect cannot but be great. The cost of illumination by this means will be materially reduced, which will, of course, lead to a wide expansion; and, at the same time, the output of every station, rated in lamps, will be correspondingly increased.

The steam turbine, which had languished for many years, now became a factor in central station design. The tendency toward increase in size of units had gone steadily forward, so as to benefit by the higher efficiency of large reciprocating engines. The steam turbine checked for a time this tendency by offering an efficient prime mover in smaller sizes. Moreover, the character of the drive was excellent for this purpose, and the small floor space brought about much appreciated economy in the station design. By this time the central stations had become large and complex. High-tension distribution had been generally adopted for large cities, current being transmitted to substations and transformed into the kind desired.

Along with the growth of the electric lighting industry went the spread of the electric motor as a means of driving machinery. This took place not only in small shops and other places where it was inconvenient to employ steam or other power, but in large workshops, in factories, and everywhere where many machines are driven. The old plan of driving from a line shaft by means of belts involved many disadvantages not incident in the motor drive, but a feature of more weight than this was the fact, soon realized, that the individual driving of tools made possible an increased output of the shop and improved the quality. The year 1899 is notable for the introduction of the electric motor in the abattoirs of the firm of Armour & Company, Chicago, and also on two battleships, where it replaced the old, inefficient small steam engine. To-day this system has become the standard for factory driving.

The advance in electric railways during the past few years has been in several ways. A still greater expansion of the interurban and suburban lines has brought this system in competition with steam roads; on the other hand, the steam railroads themselves have been forced, in some cases, to turn to electric traction to overcome certain local difficulties, and this has led to the development of enormous locomotives. The work was first started in New York city, where the conditions were particularly acute, and the year 1902 marked the letting of the contract for the electrification of the New York Central & Hudson River Railroad's New York city terminal. The following year the Pennsylvania Railroad decided to pass under New York by means of a tunnel, using electric traction for this purpose. Another important railway event during 1902 was the bringing out by the Westinghouse Electric and Manufacturing Company of a single-phase railway system. Since then several lines have been installed using this system, and the New York, New Haven & Hartford Railroad has adopted it for its New York city terminal.

During this year some highly interesting experiments were conducted at Berlin with high-speed traction. A motor-driven car was run at a speed of over 130 miles an hour. As yet no practical results have followed these experiments.

During these last years of electric railway development another important system was brought out by Sprague, which he called the multiple-unit system. This was first used on the South Side Elevated in Chicago, in 1899. In brief, it consists of adding a master controller to each car, which operates the main controller. The master controller will operate at the same time the main controller of one or any number of cars, so that trains may be made up of any length desired, each complete in itself, and all controlled from one point. This method made possible the conversion of the elevated lines in Chicago, New York, and elsewhere, where it is necessary to run trains of cars, and led to the abandonment of steam trains on elevated roads in this country. Other important installations of the multiple-unit system have also been made on surface lines.

High-tension transmission, which was started in 1902, had grown steadily, the distances of transmission had increased, and voltages had gone up. Water powers previously useless, since they were not accessible, were harnessed, and the power thus developed transmitted to places where it could be used. The success of the Niagara plant started in 1905 led to other installations at that point, so that there are now about half a dozen power houses with an output of over half a million horse-power. In California, where fuel is scarce, and water power available, as well as in other western States, the most rapid advance was made. In 1901 the transmission voltage had risen to 60,000, and power had been transmitted 225 miles. A year later 80,000 volts was tried in Montana, but 60,000 seems to be the upper limit with the present methods of construction. In 1905 power was incidentally transmitted over a distance of 300 miles in California. The success of the western plants led to a great development in the East, but here the distances are less and the systems employed are less impressive, though not less important. To-day the water powers of a state have become one of its most valued assets, due to the development of high-tension electrical transmission of power.

Electrochemical applications, with few exceptions, were not possible commercially until large sources of cheap power were available. Before the opening of the Niagara Falls plant electroplating and a few other smaller industries constituted the whole, with the exception of the storage battery, which hardly belongs in this class. That, it is true, had been greatly improved, but the old Planté and Faure types, modified by various methods of construction, were still in use. The adding of the auxiliary to the power station made necessary the development of a new branch of the art of storage battery engineering—necessary in order to adapt the peculiarities of the battery to the conditions obtaining in the station. Some very remarkable engineering work has been done in this direction. Many attempts have been made to substitute other materials for the lead and sulphuric acid of the battery, the latest and the most important being that brought out by Thomas A. Edison in 1901, in which nickel and iron take the place of the lead. This battery has, of course, required some years to demonstrate its commercial advantages. Along with the improvement in storage battery construction, went the development of the electric automobile, which has to-day become a most important factor in city traffic and which promises to work still greater changes in city life.

The opening of the first Niagara Falls plant started electrochemical developments of great magnitude in other lines. It was here that the large calcium carbide works, carborundum furnaces, and furnaces for making artificial graphite from coke were established; and here eventually came the Pittsburg Reduction Company with its method of producing aluminium. The work of this company converted aluminium from a curiosity in chemical laboratories to a common metal for use in the arts.

During these years of development while the electrical arts were being changed from the empirical methods of the pioneers to the scientific systems of to-day, a most important feature was the development of the art of electrical measurements. In this work a pre-eminent part has been taken by Edward Weston, who, with others, has placed electrical engineering work, in this respect, on a plane where it stands almost alone.

There have been a number of highly interesting applications of electric power within the last year or two, notably the invention of the telharmonium, a device for producing and transmitting music.

To-day there are two features of electrical development which are most impressive. One is the wide spread of electrical methods. Almost every industry employs this power in some form or other. In practically every line of human activity, the electric motor, the electric lamp, or some other device, is an important factor. The other feature is the enormous commercial development which has taken place. Certainly no other field of human activity can show such a record. Absolute statistics for the present year are not available. The latest compilation was made in 1902 by the Bureau of the Census, and from this some idea of the situation at the present time may be obtained. For example, at that date there were 3,620 central electric lighting stations, representing a cost of equipment of $505,000,000. The yearly income was nearly $86,000,000. This showed that the development during the twelve years preceding the census had doubled the investment as well as the income. The horse-power in dynamos at these stations was 1,600,000,

and the output 2,500,000,000 kilowatt-hours yearly. These stations employed a small army of 30,000 workers, to whom $20,000,000 was paid in wages. Eighteen million incandescent lamps were in use, and nearly 400,000 arc lamps.

The figures for the electric railway are still more astounding, and here, too, the investment and income had about doubled during the twelve years preceding the date of the census. In 1902, 987 companies operated systems having over 22,000 miles of track, and representing a cost of construction of nearly $2,200,000,000. They employed 140,000 men, and transported nearly 5,000,000,000 passengers.

The telephone systems were serving in 1902 nearly 2,300,000 subscribers, and were earning $87,000,000. They paid in wages $36,000,000 to their 79,000 employees. The cost of construction of these systems was over $366,000,000.

Compared with these figures the extent of the telegraph development is small, but actually it is very great. There are in this country twenty-five systems, which cost $157,000,000. The 28,000 employees earn $15,000,000 a year.

The newer developments, as mentioned, practically doubled during the twelve years ending 1902, and since then the development has been at a greater rate. The telephone and electric lighting industries have about doubled, the electric railways have increased about forty per cent and there have been corresponding increases in all other branches.

To supply the needs of these various systems large manufacturing establishments have grown up, whose business has become an important factor in the commercial world. The latest figures obtainable for this growth were given in the census report for the year 1905. During that year the value of the products, of all kinds, turned out, was nearly $160,000,000, this representing the factory cost, and not the selling price. The same census shows that at that time the general manufacturing industries were utilizing 1,138,000 horsepower in electrical machinery, out of a total of 14,500,000. This shows to what extent electric appliances have been introduced into the manufacturing arts; and the actual effect is greater than that indicated by the figures, as it must be remembered that a considerable part of this power is in places where the electric motor can not compete.

Certainly no other class of industries can show such stupendous growth as that demonstrated by these figures, and certainly there has been no other which can compare with the introduction of electric power, in all its forms, in its far-reaching influence on the civilization of to-day. What will be the result of the present tendencies, none can say. That the growth will go on at the present rates is hardly believable, yet one can not see anything ahead to interfere with it. There is little doubt that the influence of these new methods will be one of the controlling factors in advancing civilization, in bringing to each and all more leisure and greater comfort, and in relieving us and our servants, as it has already done, of much of the drudgery of manual labor.

Nothing has been said of the marvelous advances in physical science, particularly in the study of electrical phenomena. The work of Thomson, Lorentz, Curie, Rutherford and others has carried us far in this direction and done much to mold our ideas of nature and of nature's laws.

Agate, to Color.—Agate of a non-transparent color may be steeped for several weeks in solution of sugar of lead or iron salts, rinsed off and placed in a solution of bichromate of potash or of yellow prussiate of potash. In the first case certain softer spots on the agate will appear of a beautiful yellow, in the second colored a rich blue. If ammonia is used after the iron salts, we obtained a reddish brown color; if we mordant it first in chrome green, then in ammonia, we obtain a green color.

WASTE PRODUCTS FROM THE MANUFACTURE OF GLUE.

The raw materials or animal substances from which glue is made consist for the most part of the refuse of slaughter-houses and tanneries, old gloves, skins of

THE APPARATUS USED ON THE GERMAN RAILROADS.

hares and rabbits from which the hair has been removed in hat manufacture, also of the skins of cats and dogs, the hoofs of oxen, calves and sheep, sinews, intestines, etc. Before being made into glue, these materials must first be soaked in lime water to dissolve the portions of blood and flesh adhering to them, which would putrefy and give the glue a dark color, and to saponify the portions of fat. For this purpose these

THE NOZZLE OR BLOWER USED IN CLEANING BY COMPRESSED AIR.

glue waste materials are treated in lime-pits or in large vats with thin milk of lime for 15 to 30 days, the milk being frequently renewed during that time. When this has been done, the lime adhering to the material is washed away and the conversion of the latter into glue proceeded with.

This by-product, which contains in addition to lime the saponified fatty portions of the waste material operated upon, is called gluefat in Germany. The lime soap can be used to advantage in the preparation of machine oil. Consistent machine oil in combination with this lime soap is prepared as follows:

A boiler is half filled with the lime soap and the latter brought to the melting point. The heat is then gradually raised and the boiling kept up till the mass is so far boiled that a sample placed on a glass plate can be drawn out into long threads when touched with the finger. To ascertain the proper boiling period exactly, samples must be frequently tested during the boiling, as a mass boiled too long is useless.

After this, mineral oil is gradually added in small quantities with constant heat till the desired consistence has been obtained; this can also be tested with samples left to cool on a glass plate. Then the mass is put into a vat and stirred till it is nearly cold.

As the glue fat often contains many impurities—dirt, hairs, etc.—it must first be cleaned; this cleaning is best combined with the melting process, the dirt floating on the surface being scooped off and the deposit collecting at the bottom likewise removed.—Translated from the German of Dr. Theodor Koller in Verwerthung von Abfallstoffen aller Art.

THE USE OF COMPRESSED AIR IN CLEANING.

By Dr. ALFRED GRADENWITZ.

DURING the last few years compressed air has been put to a large number of different uses. One of the recent applications suggested in this connection is for cleaning carpets, furniture, floors, etc., of adhering dust, mud, and other dirt. It will be readily understood that the antiquated method of cleaning by brushing and beating is a rather imperfect one, the dust being only partly loosened and whirled up into the air, whence it gradually again settles on the objects just cleaned. From a hygienical point of view this process is, however, most objectionable and dangerous, as the finely distributed dust contained in the air is laden with all sorts of microbes.

Another drawback to the ordinary methods of cleaning is that the room, during the time of cleaning, cannot be used for its usual purpose, while taking the objects into the open air or to cleaning establishments involves considerable time, labor, and expense. Several methods for cleaning by means of atmospheric air have, therefore, been suggested in the course of the last few years, compressed air being at first used exclusively in this connection. For the latter purpose the air is blown by the apparatus against the tissues to be cleaned. As however the loosened dust was still free to escape into the open air this process was subject to the same drawbacks as referred to above, though to a lesser degree.

A far more successful process in which the air saturated with dust is drawn away by an exhauster, has been used successfully for a few years past, both in Europe and America. The dust contained in the tissues in the case of these "vacuum" cleaners is drawn out, is carried along by the air moving at high speed, and shortly before reaching the air pump, is caught by a filter inserted in the pipe. As, however, this system possesses a few disadvantages, the use of the combined suction and pressure effect of air, producing both actions exclusively by means of compressed air, has been suggested for cleaning purposes.

The system recently designed by A. Borsig, of Berlin, Tegel, is based on the following principles: In the mouthpiece of the apparatus terminate two tubes, one of which serves to supply the compressed air, and the other to draw the dust away. These tubes are rigidly connected together, one end of each being coupled to a corresponding piece of rubber tubing. Part of the compressed air issues in the form of fine jets from the blower, entering the tissue, and loosening and expelling the dust there deposited. The other part of the compressed air, owing to the nozzle effect, produces a vacuum drawing off the raised dust, which through a short piece of tubing is thrown into a handy transportable filter, there to be precipitated, while the air escapes in a purified state.

Though the dust is loosened and raised most energetically by the compressed air issuing from the edge of the blower, it is prevented from escaping into the surrounding air, being immediately drawn into the opening of the blower, owing to the suction effect, and thus removed most perfectly, notwithstanding that the operator in no way comes into contact with the dust.

It may be said that in the case of an exclusive use of exhausted air, the blowing effect is far less energetic, the pressure difference between the two sides of the tissues being generally sufficient only for carrying away the looser parts of the dust and mud. While a suitable combination of the suction and pressure effects as obtained in the above apparatus, would thus seem to be the most promising method, the apparatus also allows the pressure or suction effect to be used separately whenever required, as in the case of very loose dust.

As compressed-air conduits, in opposition to vacuum conduits, can be designed in any desired length, the above system will prove especially suitable in case several points have to be cleaned from one central station. As the conduits carry only cleaned air, no obstruction as in the case of vacuum tubes is possible.

The machine plant used for cleaning according to the Borsig system is relatively simple, and comprises a compressor, either of special design or of the ordinary type, of substantial and simple form, which requires little superintendence, steam engines, electro-

A COMPLETE PORTABLE OUTFIT MOUNTED ON A RAILWAY CAR.

THE USE OF COMPRESSED AIR IN CLEANING.

motors, or any other kind of prime mover, being used for its operation.

In most cases a stationary plant is preferable, though transportable plants are found especially suitable for certain purposes. The above system is used by the German Railway Department in the cleaning of railroad cars.

THE INTENSITY OF THE TROPICAL SUN AND ITS EFFECT ON THE HUMAN BODY.

By SURGEON GENERAL STENDEL.

THE high average intensity of solar radiation in the tropics is due to the great altitude of the sun and the prevalence of clear skies. The sun's rays impart little heat directly to the air but they raise its temperature indirectly by heating the ground, from which the air is warmed by conduction and convection. All regions in which the mean annual temperature of the air equals or exceeds 20 deg. C. (68 deg. F.) are classed by Supan as "tropical," while "hot" regions are those in which the mean monthly air temperature does not fall below 20 deg. C. in the coldest month of the year.

Humidity and intensity of radiation, however, are as important as temperature in determining the salubrity of a climate. The air temperature does not give any accurate measure of the intensity of the sun's radiation, chiefly because of the mobility of the air. The heated air rises and cool air takes its place. Hence the air temperature in the tropics is usually much lower than would be inferred from the heat of the sun's rays. Indeed it seldom rises, even at the equator, above the maximum midsummer temperature in Germany. Tropical climates are characterized less by extreme than by uniformly high temperatures, the lack of cool nights and the absence of winter.

The intensity of the sun's rays is measured by a thermometer with a blackened bulb. This instrument, when exposed to the sun in Germany, rarely indicates more than 60 deg. C. (140 deg. F.) but in the tropics it rises to 80 deg. C. (176 deg. F.). At Lahore in India the black bulb sun thermometer stands higher than 70 deg. C. (158 deg. F.) during seven months of the year, falls below 60 deg. C. (140 deg. F.) in only one month and at midsummer attains 80 deg. (176 deg. F.) although the maximum air temperature in the shade is only 41.7 deg. C. (107 deg. F.).

The ground is very strongly heated by the tropical sun. In the French Congo a ground temperature of 84.6 deg. C. (184 deg. F.) has been observed and eggs can be cooked hard by placing them in the sun, for albumen coagulates at 80 deg. C. (176 deg. F.). A temperature of 69 deg. C. (156 deg. F.) was observed in loose sand two inches below the surface.

We will now consider the effects of the sun's rays on living organisms. All green plants require light and heat, under the influence of which chlorophyl is produced and performs its function of decomposing carbon dioxide. Seeds, however, sprout best in the dark and sunlight is fatal to many of the lower vegetable organisms. Among these are the schizomycetes, which include the bacilli of tuberculosis, typhoid, cholera, fever, diphtheria, and other diseases, which are killed by a few hours' exposure to direct sunlight.

Though most animals require light there are some that can live without it. In the tropics, especially, there are many nocturnal animals and many others which, though not truly nocturnal animals, usually sleep during the day and seek their food at night. Among these are most of the large carnivora. By day the sunlit African steppes are inhabited only by gorgeous birds and insects, but at night a chorus of animal voices is heard.

Some African animals carefully avoid even brief exposure to the sun. The termites, for example, devour all the inner parts of a stump but leave a thin shell which protects them from the sun and gives no indication of their work. There is a widely distributed tropical species of ants, only half as large as European ants. They are very active and voracious and make it necessary to keep provisions in closets mounted on feet which rest in dishes of petroleum or some other liquid. I observed that these ants carefully avoided the sun. I put some of them on a plate in the sun and found that they curled up and died in a few seconds. I repeated the experiment many times and always with the same result.

Man also requires light. Children who live in dark houses are liable to abnormalities of growth, especially malnutrition of the bones. Men who live indoors and never expose themselves to sunlight have a pale complexion which we call "sickly" while the bronzed skin of outdoor workers suggests vigorous health. Light also has a striking effect upon our spirits. Bright, sunny days promote cheerfulness and cloudy weather produces gloom. Light stimulates the nerves and rouses men to action but the darkness of night brings sleep. Mental work is accomplished most easily and quickly in brightly lighted rooms.

Hence it might be inferred that the dazzling light of the tropical sun would promote health, cheerfulness and activity, and the cheerful disposition of the negro appears to support this inference. The negro is not active but his indolence is the result of living in a climate which furnishes all the necessaries of life in return for little or no labor.

White sojourners in the tropics are familiar with the stimulation of the nervous system by the tropical sun, but they know that in many cases this stimulation is excessive and therefore injurious. Extreme nervous irritability is a common symptom. The newcomer feels a keen desire for action, he is impatient of delay and at night he can not sleep. Irritability and nervous weakness follow and then comes a condition of nervous exhaustion with diminished sensibility and a tendency to indolence and apathy. Other causes, which we can not here discuss, contribute to this result.

The intense solar radiation greatly impedes the automatic regulation of bodily temperature. According to Rubner the effective external temperature which corresponds to the bodily condition is obtained by adding to the temperature of the shade thermometer 47 per cent of the difference between that and the sun thermometer. Rubner's experiments were made on clipped and shaved dogs. Clothed human beings are in more favorable conditions.

Usually the sun's rays fall directly only on small portions of the body, particularly the face and hands. Light colored clothing reflects much of the radiation but transmits a portion. Dark garments neither reflect nor transmit much but absorb most of the radiation and therefore are strongly heated. Theoretically tropical garments should be white or very light outside and lined with yellow or red cloth but in practice thin, light colored and unlined garments suffice, as the rays which penetrate them are not strong enough to injure the skin.

On the bare skin the tropical sun produces an effect called sunburn which resembles the burns caused by flame. The skin turns red and itches painfully for a day or two. Then the outer skin becomes dry and peels off. A few days later a new and darker skin appears which retains its dark color permanently if frequently exposed to the sun. This new yellow brown skin is more resistant than the old and is not easily affected by severe sunburn.

This kind of sunburn is familiar to Alpine climbers under the name of "glacier burn." On high mountains the sun's rays are very powerful because they are not greatly weakened by their passage through the rarefied atmosphere. The effect is increased by reflection from ice and snow. Hence severe sunburn may occur on mountains in the temperate zone at low air temperatures. This is explained further by the readings of the black bulb sun thermometer. On the Diarolezza pass, 2,980 meters (9,770 feet) above sea level, the altitude of the sun being 60 deg, Frankland observed a sun temperature of 59.5 deg. C. (139 deg. F.) when the shade temperature was only 6 deg. C. (43 deg. F.), a difference of 53.5 deg. C. (96 deg. F.). At an elevation of 3,500 meters (11,480 feet) in the Himalayas Dr. Cagley succeeded in boiling water in a blackened vessel exposed to the sun and sheltered from the wind. At this elevation water boils at 88 deg. C. (190 deg. F.).

Widmark and others have proved that sunburn is caused rather by the violet and ultra violet rays than by the rays of greater wave length and thermal intensity. Even tropical sunburn produces no serious effects when it is confined to a small area, but the skin is so important an organ, especially in the tropics, that if much of it is destroyed the whole organism suffers. Even scalding, the most superficial variety of burning, is fatal if it extends over half the surface of the body. Hence it is dangerous to expose a large surface to the direct rays of the tropical sun. Sun baths in the tropics are suicidal. In Bagamoyo a young missionary bathed in the sea in sunshine, nude except for a tropical helmet. His entire back was sunburned and a general illness followed which nearly proved fatal. In the tropics it is not safe for Europeans to bathe in the sea between 7 A. M. and 5 P. M.

The skin is bronzed by continued exposure to the sun without severe sunburn and the skin so bronzed is less sensitive than white skin to the rays of the sun. The tanned Alpine guides have no fear of "glacier burn." All natives of tropical lands are protected by their dark skins. At birth negro infants are as fair as our own but the skin darkens very rapidly.

At first view dark skin appears as little suited as dark clothes to a tropical climate. Why the negro's skin does not become intensely heated by absorption of incident rays is not fully understood but a partial explanation is given by his profuse perspiration. His dark skin, however, admirably protects the interior of the body. Schmidt has shown that a negro's skin transmits only half as much radiant heat as a European's skin emanates.

When the solar radiation is analyzed by sending it through a prism it is found to contain, besides the luminous rays that produce the colored spectrum, two classes of non-luminous rays. These are the infra red

THE EASY MANNER IN WHICH CARPETS CAN BE CLEANED.

A COMPLETE PORTABLE CLEANING OUTFIT.

THE USE OF COMPRESSED AIR IN CLEANING.

rays of great energy and heating power at one end of the spectrum, and the ultra violet rays of little energy but great chemical activity at the other end.

No very powerful source of light is needed to prove that the heat-producing rays can penetrate the human body. Schmidt has investigated the penetration of various bodily tissues by the rays of a 65-candle-power Nernst lamp, employing a thermo-electric battery and a galvanometer for the measurement of the radiant heat transmitted. He found that the blood and the brain are the tissues most impervious to radiant heat. Comparing layers of equal thickness exposed for equal times to the same radiation, and calling the galvanometer deflection for blood or brain unity, the deflections for other tissues were: bone 2.5, fat 4, and muscle 6.

The thermal rays penetrated appreciably in a few seconds through the hair and skull of a cadaver. Nevertheless, thick hair was found to present a serious obstacle to the rays. These experiments show that the rays of the tropical sun can penetrate to the interior of the body and cause internal injury. The brain is especially sensitive to heat. The central nervous system reacts to very slight changes of temperature and it is affected in all fevers. This is shown by general fatigue and lassitude and incapacity for mental labor. In high fevers the brain exhibits the perverted activity known as delirium, as it does in mental and brain disease. In fever the temperature of the brain is increased because the temperature of the blood and the entire body is several degrees above the normal. But when the rays of the tropical sun fall on the head and penetrate the skin and the skull, the brain or part of it may be heated although the general temperature of the body remains normal. This elevation of the temperature of the brain causes sunstroke, an accident to which Europeans in the tropics are very liable.

True sunstroke seldom, if ever, occurs in human beings in temperate latitudes (in Europe). It is essentially different from heat stroke. Heat stroke occurs only in men engaged in hard work, for example, heavily burdened soldiers on the march, and especially in calm, sultry weather. It is always associated with great elevation of the temperature of the whole body, as in fever, though the brain is the organ most injuriously affected. Sunstroke, on the contrary, often occurs in persons who are perfectly idle but exposed to a hot sun, especially on the water which adds reflected rays to the direct rays of the sun. At first there is no general rise of temperature but this comes later as a result of the reaction of the organism to the stroke. If we analyze the genesis of sunstroke, with the aid of Schmidt's experiments, we find that the sun's rays easily penetrate the skull and fall upon the outer layer or cortex of the brain. This opposes more resistance to penetration by the rays and for that very reason becomes heated more strongly than tissues which readily transmit radiant heat. This outermost layer of the brain consists of the most important part, the gray matter, which contains the active nerve cells. So it is easy to understand that exposure to the tropical sun may suddenly cause serious injury to the brain which may soon result in death. Goldscheider has discovered that visible alterations in the cells of the central nervous system are produced by overheating the body.

Schmidt has endeavored to ascertain by experiment whether sunstroke is caused by the heat-producing or the chemically active rays. He proved that the latter also penetrate the tissues to such an extent that objects can be photographed through a human skull, but nevertheless he regards radiant heat as the most probable cause of sunstroke. Möller, of Stockholm, has confirmed this view by experiments on animals with the rays of the electric arc which have great chemical activity but produce comparatively little heat. He succeeded in causing sunburn on the skin, but failed to produce any of the phenomena of sunstroke.

Protection against sunstroke is given by a suitable covering for the head. For use in the tropics this covering must satisfy the following conditions: It must consist of a compact material, as impenetrable to the sun's rays as possible; it must be light in weight and afford thorough ventilation, and it must have a broad brim, especially behind for the protection of the back of the neck. All these conditions are satisfied by the tropical helmet.

The tropical helmet is a certain protection against sunstroke and every European in the tropics should wear it. I recall the case of a man who went into training for a tropical expedition. He had the idea that Europeans could preserve their health in the tropics by adopting the habits of the natives. To accustom himself to exposure to the sun he took long walks in midsummer bareheaded, and on the outward journey he exposed himself in the same way to the continually increasing heat of the sun. In German East Africa he was repeatedly warned of his danger but he persisted in going bareheaded. One day he returned from a short sea trip during which the direct rays of the sun fell on his head and the reflected rays on his face and neck. He said that he had eaten some canned meat which caused him to vomit, that canned meat was not suitable for the tropics and that the natives did not eat it. He ordered all the canned meat to be removed from the stores of the expedition, then he went to bed. When I was summoned, soon afterward, I found him unconscious and in a few hours he was dead. The autopsy proved that he had died of sunstroke. There was nothing the matter with his stomach; the vomiting was caused by the injury to the brain.

His theory was not entirely false, but the process of acclimation requires many years, instead of a few weeks or months. Europeans who have lived long in the tropics can expose themselves to the sun with comparative impunity. One "old African" told me that at first he had feared sunstroke and worn the helmet, but that now he never wore it. Such statements combined with an inadequate conception of the time required for acclimation may easily bring a newcomer to his death.

We have seen that the intense solar radiation is a factor of the tropical climate that may cause serious bodily injury, but we have learned that its dangers may be averted by simple precautions. We have seen, also, that the human body possesses natural means of defense. Against the other factors, especially the high temperature of the air and the great humidity, we have no such certain and simple safeguards. But the body possesses a store of reserve force for emergencies and this should be kept at its normal amount by such a mode of life as will maintain the general health. A knowledge of tropical dangers and tropical hygiene is of the greatest importance to all Europeans visiting the tropics, especially to persons of the Germanic race who are less accustomed to heat and hence less easily acclimated in the tropics, than members of the Romanic races.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Die Gartenlaube.

LOADING OF ROPE.

A LITTLE taste of elementary mechanics is sometimes worth while. We must not forget that while the action of all mechanisms is controlled by simple principles, these principles are not always as well understood as they should be by men who have the handling and care of property worth many thousands of dollars, to say nothing of the danger to human life caused by seemingly inexcusable ignorance. These remarks apply with special force to the handling of material by cranes or derricks, using ropes and sheave blocks. A careless workman may see a load of several tons handled safely with pulley blocks and a wire rope of perhaps not more than ½ inch diameter. The construction of the pulley blocks which permits of such a load being safely handled of course comprises a number of sheaves in both a stationary and moving block which divide the load among several ropes. For example, the accompanying cut taken from the American

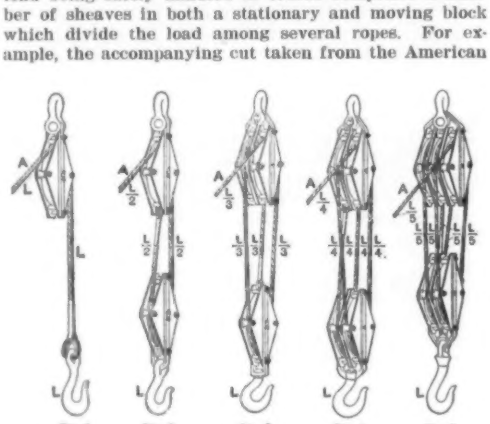


Fig. 1 Full load on rope. Fig. 2 Strain on rope is one-half the load. Fig. 3 Strain on rope is one-third the load. Fig. 4 Strain on rope is one-fourth the load. Fig. 5 Strain on rope is one-fifth the load.

Wire Rope News (with a slight change) illustrates the conditions in loading on a rope with pulley blocks. The first figure shows that with one block the total load on the hook is transmitted to the rope at *A*, but in Fig. 2 only half the load is so transmitted, and progressively up to Fig. 5 we find that only one-fifth of the load on the hook is carried by the rope at *A*. So supposing that the tackle will safely carry ten tons on the hook it by no means follows that the wire rope alone will carry that load. On the contrary the chances are that it would not sustain it at all unless a high factor of safety was employed. The cuts show graphically the division of loading among the sheave ropes, being respectively $L/2$, $L/3$, $L/4$, and $L/5$.—Machinery.

THE MANUFACTURE, DENATURING, AND THE TECHNICAL AND CHEMICAL UTILIZATION OF ALCOHOL.—I.

By M. KLAR, Chief Chemist of F. H. Meyer, Hannover-Hainholz, Germany.

THE DISTILLATION OF ALCOHOL.

ETHYL alcohol is represented by the chemical formula $CH_3CH_2CH_2OH$, has a specific gravity of 0.795, a heat of vaporization of 202.4 deg. F., a boiling point of 173 deg. F., and a specific heat of 0.453. It may be said in general that the chief source of alcohol is found in the vegetables containing carbo-hydrates; nature provides us with plants of this character in manifold forms. First are the fruits, including cherries, plums, and other stone fruits, kernel fruits, berries, grapes, currants, raisins, etc. Then we have the grains—rye, barley, wheat, oats, corn, dari, rice; and finally there are the roots and similar vegetables, such as the potato, sugar beet, carrot, etc. In recent years a demand has also arisen for waste wood material, which usually consists of cellulose, for the purposes of alcohol manufacture.

The choice of the raw material is governed by the average price of the carbohydrate per unit of weight of the produce, and by the revenue conditions which must be fulfilled in manufacture. Thus, in the United States corn and rye have hitherto formed the chief raw material for distillation. In Germany the raw material of greatest importance is the potato; in Austria-Hungary, corn and potatoes; in Russia, potatoes, rye, corn, and barley; in France, molasses and beet roots. Of the raw materials mentioned, those containing starch, particularly corn, rye, barley, and potatoes, constitute the greater part of the substances used in the manufacture of alcohol.

The percentages of starch, or rather of starch and sugar, which these products contain differ considerably, as is shown by the following table, which represents average values:

	Starch. Per cent.	Sugar. Per cent.
Corn	60	3
Rye	63	3
Wheat	65	3
Barley	60	3
Oats	53	3
Potatoes	18	3
Undried green malt with malt germs	40	3
Dried malt without malt germs	68	3

THEORETICAL CONSIDERATIONS IN THE ALCOHOL-FORMING PROCESS.

In order to convert the starch, $C_{12}H_{20}O_{10}$, contained in the raw material, into alcohol, it is necessary to change it first into a sugar capable of fermentation, maltose, $C_{12}H_{22}O_{11}$, or dextrose, $C_{12}H_{24}O_{12}$. This conversion of the starch into sugar is effected either by the action of mineral acids upon the starch, which converts the latter principally into dextrose, or by the action of organic ferments upon the starch, in which the principal conversion substance is maltose. Generally, a ferment, the so-called "diastase," is used in the production of alcohol for converting the starch into sugar. Diastase is an albuminous substance found in all germinating grains, and in distillation it is usually employed in the form of germinated barley—malt—as this particular grain is adapted for the production of a more efficacious malt than any other.

Through the action of the diastase of the germinated barley on the gelatinized starch, resulting from a previous impasting, soluble starch is first produced, which under continued action changes into dextrines and the saccharine substances isomaltose and maltose. These two substances are easily converted into alcohol and carbonic acid by means of yeast; on the other hand, the dextrines and isomaltose are fermented with much greater difficulty than maltose. For this reason care must be taken to restrict the formation of isomaltose and dextrines as far as possible by properly conducting the process of fermentation. This can be accomplished by the correct choice of the degree of concentration of the solution to be fermented, the proper proportion of starch with respect to diastase, and a suitable duration of the action.

After the starch has been converted by the diastase into maltose, the latter must be changed in a subsequent process into alcohol. The latter process is carried out by means of the yeast. Yeast is a monocellular plant organism, a kind of fungus belonging to the Saccharomycetes of the species *Saccharomyces cerevisiæ*, which propagates through the formation of spores and which converts the maltose as well as other saccharine substances capable of fermentation into alcohol and carbonic acid, according to the formula:

$$\underset{\text{Sugar}}{C_6H_{12}O_6} = \underset{\text{Carbonic Acid}}{2CO_2} + \underset{\text{Alcohol}}{2C_2H_6O}$$

In addition a certain number of volatile and non-volatile by-products of fermentation are obtained; these are subjected to a further process of distillation, and may be included under the general name of "fusel oil."

At the present time we have no absolutely satisfactory explanation of the processes which take place during the fermentation of sacchariferous substances. There is, however, much to be said in favor of Buchner's theory that the yeast cells contain a ferment, "zymase," similar to diastase, which possesses the power to split up the sugar molecule into alcohol and carbonic acid. Of the many kinds of yeast in existence, which are distinguishable in their methods of propagation, their external appearance, and their faculty of inducing fermentation, certain known and approved varieties only can be used in distillation, and one of the most important tasks of the distiller is to choose a suitable pure culture yeast and to keep it pure by pure cultivation.

THE PRODUCTION OF ALCOHOL FROM STARCH.

From the chemical formulas:

Starch	$C_{12}H_{20}O_{10}$	= 324
Maltose	$C_{12}H_{22}O_{11}$	= 342
Alcohol	C_2H_6O	= 46

it appears that from 324 kilogrammes of starch, of 100 per cent, 184 kilogrammes of alcohol of 100 per cent, or 233 liters of 100 per cent, equal to 108 proof gallons having a specific gravity of 0.920 can be obtained. In other words, per ton (2,200 pounds) of starch of 100 per cent, 333.33 proof gallons having a specific gravity of 0.920, equal to 188 gallons of 100 per cent alcohol, can be obtained.

The figures given above, which are purely theoretical, naturally cannot be obtained in practice, because of the losses which occur. The latter include, first, 0.5 to 2 per cent of the quantity of the mashed starch because of imperfect development of the latter; from 4 to 7 per cent remains unfermented; and 7.5 to 12 per cent enters into bi-fermentation. This leaves, at the most, about 84 per cent of the starch to be converted into alcohol. Allowing for these losses, it appears that with careful management one ton of starch

will yield about 280 proof gallons, having a specific gravity of 0.920.

Assuming the starch content of corn to be 60 per cent, we find that from one ton of corn, 60 per cent of which is starch, 168 proof gallons or 95 gallons of 100 per cent alcohol can be obtained from the 39.2 bushels. Allowing for a daily production of 6,674 proof gallons of alcohol, the following quantities of materials are necessary, assuming corn to contain 60 per cent of starch, barley 60 per cent, rye 63 per cent, wheat 65 per cent, and potatoes 18 per cent: corn, 39 to 40 tons, about 1,580 bushels; barley, 39 to 40 tons, about 1,640 bushels; rye, 38 tons, or 1,450 bushels; wheat, 36 tons, or 1,320 bushels; potatoes, 138 tons, or 5,200 bushels. The above figures include the barley required for the necessary malt, as well as the grain and the malt necessary for the production of the yeast. Including in the alcohol obtained the foreshots, the pure alcohol, and the trailings from each ton of corn—39.2 bushels on an average—95 gallons of 100 per cent raw spirit can be obtained. This quantity on rectification yields 6 per cent foreshots, equal to 6 gallons of 95 per cent; 4 per cent trailings, equal to 4.2 gallons of 91 per cent; 0.5 per cent fusel oil, equal to 1 gallon of 50 per cent; and 87 per cent pure alcohol, equal tó 86 gallons of 96.5 per cent.

As said before, neither saccharization nor fermentation runs its course smoothly in practice, as aside from alcohol, unfermentable sacchariferous substances (dextrins) are formed, as well as a small amount of non-volatile products including glycerine, lactic acid, succinic acid, and volatile products like aldehyde, propyl-alcohol, isobutyl alcohol, amyl alcohol, etc. These by-products in the production of alcohol are not lost, however, for both the volatile and the non-volatile substances are obtained either in the process of distillation or are found later in the wash.

YIELD OF WASH.

About 1,000 gallons of sweet mash are obtained from one ton of corn, from which approximately 1,200 gallons of spirit-free wash result through the condensation of the live steam used in the distillation. These 1,200 gallons of wash contain all the non-volatile products arising in the process of fermentation. From one ton of corn, 39.2 bushels, there are obtained about 0.37 to 0.40 ton of air-dried wash, the composition of which is as follows:

	Per cent.
Moisture	12
Nitrogenous substances	24.6
Fat	14.7
Non-nitrogenous extractive substances	30.6
Woody fibers	14.5
Mineral substances	3.6

Regarding the second, third, and fourth items of the table as the nourishing substances of the wash, we find that from one ton of corn, on an average 210 pounds of nitrogenous substances, 308 pounds of non-nitrogenous extractive substances, and 123 pounds of fat are obtained, representing a considerable quantity of valuable food for cattle and other animal organisms. From this it can easily be seen that the wash, either moist or dried, offers a most valuable fodder. It is an inexpensive one when compared, for instance, with wheat bran, a ton of which will cost approximately $16 to $17, whereas a ton of the wash can be obtained for $10 to $11.

YIELD OF VOLATILE BY-PRODUCTS.

The volatile substances, other than ethyl alcohol, produced during the process of fermentation are found, together with the spirit, in the so-called crude alcohol. Of these volatile substances, the following have been exactly identified: Acetaldehyde and some of its homologues, such as acetic ester, formic ether, and acetal; propyl alcohol, isobutyl alcohol, amyl alcohol, furfurol, pyridine bases. The substances enumerated in the first group, having lower boiling points, are found during rectification in the foreshots; those of the second group, with higher boiling points are found in the trailings, from which they are isolated by washing with water, and they constitute the valuable mixture of propyl, butyl, and amyl alcohol, known to the trade under the generic title of fusel oil.

The crude alcohol distilled from corn and regarded as 100 per cent alcohol contains the by-products in the following proportions: Aldehyde, about 0.004 volume per cent; esters, about 0.050 volume per cent; fusel oil, about 0.500 volume per cent. Accordingly, from the 95 gallons of alcohol of 100 per cent obtained from one ton of corn, about 0.0038 gallon of aldehyde, 0.0473 gallon of ester, and 0.4750 gallon of fusel oil are produced.

The aldehyde and esters are rarely isolated, but are as a rule mixed with alcohols of inferior quality, and are thus sold. Fusel oil, on the other hand, is always separated out, and represents a valuable by-product of distillation. On an average its composition is as follows:

	Per cent.
Water	10
Alcohol	6
Amyl alcohol	65
Propyl alcohol	3
Isobutyl alcohol	14
Residuum	2

Fusel oil is usually sold to special refineries, where it is separated into pure isobutyl alcohol, used principally in the manufacture of artificial musk, and into amyl alcohol and amyl acetate. The price of this product is about 85 cents per gallon.

To sum up, the yield from one ton of corn, 39.2 bushels, is as follows:

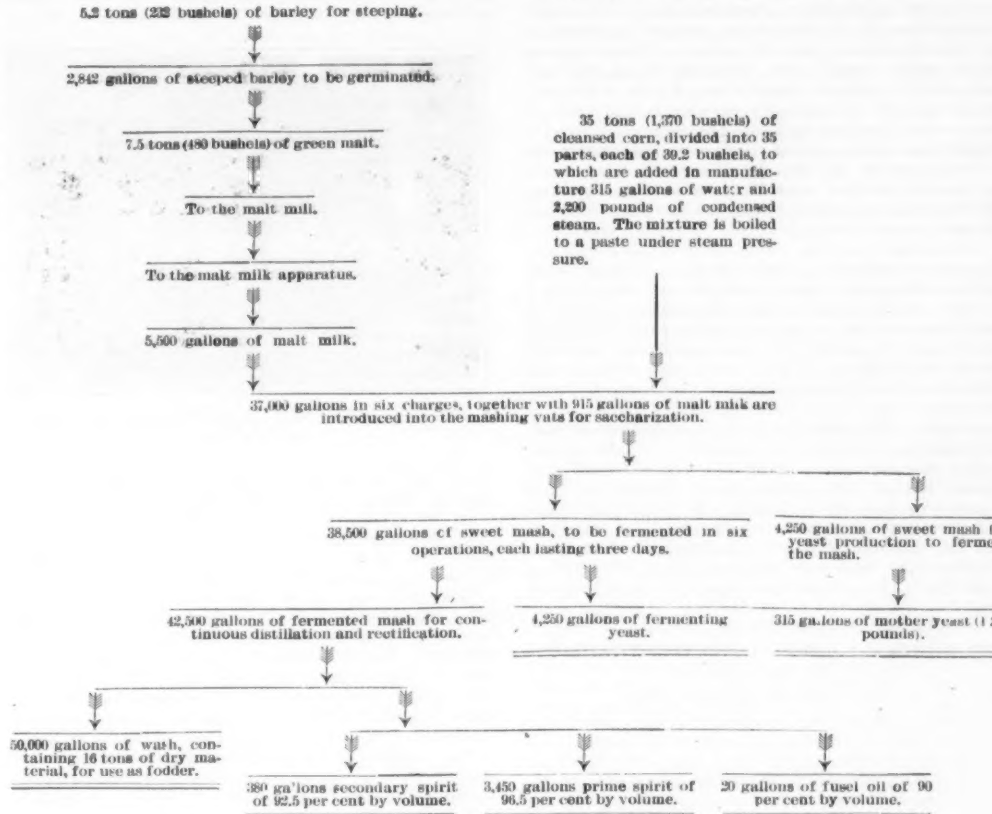
6 gallons of foreshots of 95 per cent.
4 gallons of tailings of 91 per cent.
86 gallons of pure alcohol of 96.5 per cent.
200 pounds of nitrogenous matter and 123 pounds of fat in 1,200 gallons of wash, also 308 pounds of non-nitrogenous extractive substances.

The nutritive substances of the wash are equal in food value to about 0.62 ton of bran wheat.
0.475 gallon of fusel oil of 90 per cent.

THE DIFFERENT PHASES OF ALCOHOL MANUFACTURE FROM STARCHY RAW MATERIALS.

In the following schematic outline are shown the principal operations in the distillation of 40 tons of corn:

OPERATIONS OF A DISTILLERY USING 40 TONS (1,570 BUSHELS) OF CORN PER DAY.



(To be continued.)

PROCESS OF PRODUCING BUBBLELESS PLASTER.

THE object to be attained by this process is such a mixture of the burned, ground and colored plaster, with water as to produce a mass, which after hardening, will be free from bubbles. This is of the greatest importance to manufacturers of porcelain and earthenware, sculptors and plaster cast makers, generally for all industries requiring fine molds, free from bubbles in their processes. The demand for plaster casts free from bubbles, has always existed and many attempts have been made to obtain the desired result. One method tried has been, in calcining the plaster, to keep to a certain temperature, the opinion being that with this means of expelling the water of crystallization from the gypsum, it will remain free from bubbles on being again mixed with water. Inasmuch, however, as this process failed to produce plaster free from bubbles and the trouble could not be attributed to the plaster, which was wholly freed from air, it was necessary to fall back on the theory that it was the water that was to blame for the formation of bubbles in the plaster, nothing else being added to it, and this supposition proved to be the correct one, for after mixing with ordinary river or spring water, the plaster, in passing from the fluid into the solid condition, i. e., in setting, as a matter of fact, takes up the minute air bubbles. To render such absorption of air impossible, we practise, as a new process in the production of plaster free from bubbles, the mixing of plaster with water that contains no air, that is distilled, freshly boiled water. The plaster is mixed with the water deprived of air in a suitable vessel, the isolated air bubbles that may rise to the surface during mixing are removed and after it is thoroughly mixed, the mixture transferred to the mold for which it is intended, shaking it, as required, more or less vigorously, removing any bubbles that may possibly rise to the surface and finally, allowing it to set. Hereupon, by reversing the mold, the hardened mass—the plaster cast—is set free and will be found to contain no bubbles.

PRODUCTION OF ARTICLES FROM PLASTER MIXED WITH DISTILLERY SLOP. (RESIDUARY LIQUORS.)

In the earthenware manufacturing industry, in the manufacture of ridge tiles or hollow tiles, Dutch pans, store tiles, flat tiles and similar shapes, molds have been used that have been a source of all sorts of trouble. Either they were too dear, or they did not easily release the molded pieces. In the case of plaster molds, it was found that they were not sufficiently durable. Especially was this the case where clay of a sandy character was used; after a few thousand pieces had been molded, the pattern became either entirely shapeless or dulled. In addition, the goods, after burning, often displayed a very imperfect color, due to the plaster particles set free by pressing in the mold. This, of course, affected the salability of the ware unfavorably. The experiments that finally led to the discovery of the process under discussion, were undertaken in order to impart greater hardness. By means of additions of Glauber's salt, sulphate of copper (blue vitriol) and sulphate of iron (green vitriol) to the plaster, also by the use of combinations of plaster and cement, in varying proportions, it was certainly possible to produce molds of considerable hardness and solidity, but from molds made from all these substances, it was exceedingly difficult to detach the molded bodies.

On the other hand, the addition of very small quantities of distillery swill to the plaster, materially delayed its setting, thereby facilitating greatly the making of the molds. Molds made with the swill-mixed plaster were considerably harder than those made from plain plaster and at the same time, the molded article was easily freed from the mold. The sticking of a modeled piece in the mold never happened where molds made from swill-mixed plaster were used. The swill available for use for this purpose was not only the "slop" obtained as a residual product by the desaccharification of molasses, with the aid of strontium, but also the residue of alcoholic distillation (potato swill). In order to insure the presence of a constant proportion of dry substance, it was necessary to use these residues at a concentration of 60 to 70 deg. Brix. With the same amount of dry substance, the potato residue shows approximately the same results as the molasses residue.

The swill employed for the above experiments, for the most part of 73 deg. Brix, showed the following results. If to 20 parts of plaster, which, mixed with 100 parts of water, would set in 5 minutes, 1 part of the residual liquor be added, the setting will be delayed until from 1 to 2 hours; if the quantity of swill is doubled (i. e., 2 parts to 200 parts of plaster) the mass will not become hard until after 40 hours. It is therefore possible to absolutely control the setting period, according to the quantity of residual liquor employed. The swill plaster mass adapts itself closely to the original model and furnishes very sharp molds, which when saturated with water readily release the clay.

PROCESS FOR ACCELERATING THE SETTING OF HYDRAULIC PLASTER.

The process is based on the well-known property possessed by potash salts, of combining with gypsum to form a double salt, thereby promoting the hardening process in gypsum mortar. This treatment of plaster with potash salts has until recently possessed no technical importance, inasmuch as in working with ordinary plaster, burned at a low temperature that sets of itself quite rapidly, the retarding of the setting process, by the addition of glue, etc., has rather been sought.

The acceleration of the setting process in the case

of hydraulic gypsum, which takes weeks to fully bind the water, is another matter. This slowness in taking up water, is dangerous to objects freshly prepared from hydraulic plaster and exposed to the air, because in a short time, they lose so much moisture by evaporation, that for lack of water of crystallization or constitution they cannot harden. In acceleration of the setting process therefore, we have a means of making the influence of evaporation harmless.

Even in the employment of hydraulic plaster for making floors, in which the influence of evaporation is reduced to a minimum, the acceleration of the hardening process is of great value, because it permits of the immediate treatment of the mortar freshly spread on the floor (beetling, etc.) provided it has been prepared thick enough to begin with. Where it has been mixed thin, it is necessary to wait for at least an hour, before starting to finish the floor surface. The significance of the possibility of such an uninterrupted working process can best be understood by perusing the chapter in "Der Gips Baumeister," by Heusingen von Waldegg, in which he describes the former method of laying plaster floors.

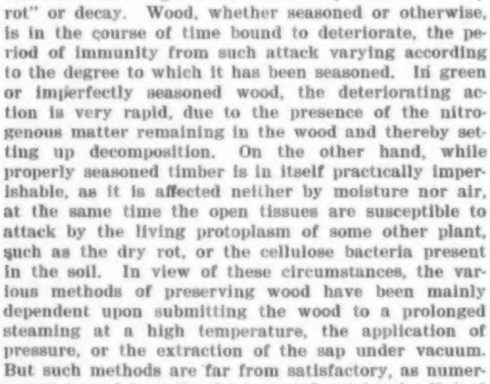
The mortar is prepared as follows: first make a solution of sulphate of lime in ordinary cold water and stir the plaster into this in the ordinary manner. A 1 per cent solution of crude (Stassfurt) sulphate of potash and of this solution 30 to 35 parts by weight, to 100 parts by weight of hydraulic plaster, suffice to retard the setting of the plaster for several hours. The hydraulic plaster is best used in a coarsely ground condition.

In place of the sulphate of potash, other potash combinations can be used, for instance, caustic potash, potash, and even crude substances like wood ash, that contain potash. The use of alum, however, which is used to promote the hardening of floors made from over-burned gypsum, is not included, aside from the fact that for the purpose in question, its use has not been attended with any practical results.—Translated from Marco Pedrotti's "Der Gips und seine Verwendung."

THE POWELL PROCESS OF PRESERVING WOOD WITH SACCHARINE.

By Our English Correspondent.

During the past few months extensive tests have been carried out in England, and other parts of the world with timber utilized for a wide variety of purposes, which had been previously preserved by the Powell wood process. Numerous efforts have been made by various experimenters to devise a system whereby the durability of timber might be considerably increased, and to protect it against the inevitable and insidious fungal attack commonly known as "dry rot" or decay. Wood, whether seasoned or otherwise, is in the course of time bound to deteriorate, the period of immunity from such attack varying according to the degree to which it has been seasoned. In green or imperfectly seasoned wood, the deteriorating action is very rapid, due to the presence of the nitrogenous matter remaining in the wood and thereby setting up decomposition. On the other hand, while properly seasoned timber is in itself practically imperishable, as it is affected neither by moisture nor air, at the same time the open tissues are susceptible to attack by the living protoplasm of some other plant, such as the dry rot, or the cellulose bacteria present in the soil. In view of these circumstances, the various methods of preserving wood have been mainly dependent upon submitting the wood to a prolonged steaming at a high temperature, the application of pressure, or the extraction of the sap under vacuum. But such methods are far from satisfactory, as numerous tests and investigations carried out by the United States government have conclusively proven. Instead of acting as a preservative, such methods accelerate



THE POWELL PROCESS CYLINDER BEFORE CLOSING.

the deterioration of the wood; for although the albuminous matter contained in the sap is coagulated, the fibers and tissues are seriously affected, and consequently the strength of the wood is greatly impaired. For this reason the government has emphatically condemned all processes dependent upon the utilization of high pressures or vacuum.

The Powell preserving process differs entirely from any previously exploited system, both in the material employed for displacing the sap and in its method of application. It has long been recognized that to preserve wood effectively and at the same time cheaply and quickly, some method of impregnation should be adopted. Yet here again many difficulties present themselves. The substance employed must not in any way affect the subsequent working of the wood, or impair its surface, so as to militate against painting or polishing; nor must it increase its inflammability, while it must at the same time be absolutely odorless. In the Powell process these ends are fully attained, since the material employed consists of sugar, in one or another of its numerous varieties, molasses being used for cheap timber that requires no subsequent surface finish, such as joists, paving blocks, and so

POWELLIZED ASH FELLIES READY FOR DELIVERY.

forth, and saccharine for the more expensive woods such as mahogany, satin walnut, or red gum, largely used for decorative work and furniture and where a high finish is required. It may not seem at first sight that such a substance as sugar would properly answer the purpose, but the Powell process has demonstrated that such is the case, and in some instances to a remarkable degree. Sugar, especially that obtained from beets, is a simple, stable, carbohydrate, incapable, in the absence of soluble nitrogenous matter, of nourishing septic organisms. It furthermore has a high boiling point, and possesses an extraordinary power of diffusion through the wood, its potentialities in this direction being far in excess of water.

The process is furthermore extremely simple and inexpensive, the greatest cost being in regard to the quality of sugar to be employed. This is practically insignificant for the cheaper grades of molasses, and proportionately higher when saccharine is required. The essential part of the method consists in boiling the wood in a sugar solution, after which it is artificially dried and is then ready for use.

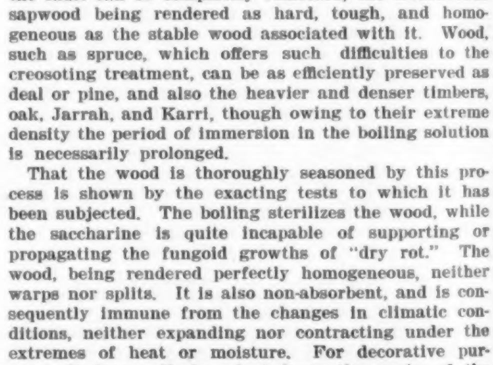
By this means any kind of wood can be preserved quickly, whether it be newly-felled green timber or wood that is partly seasoned naturally, though the best results are obtained with timber in the green state. This peculiarity arises not from any curious affinity for the green wood on the part of the solution, but is due to the fact that very often partly seasoned wood has developed cracks and shakes. The wood upon arrival at the works is immersed in a tank containing cold water to which has been added a certain percentage of sugar. This solution is then gradually brought to the boiling point, and is maintained at this temperature for a certain period, varying with the size and description of wood under treatment. The latter is then withdrawn from the tanks and is ready for drying. At the London works of the Powell Wood Process Syndicate, which is using the patents, the boiling is carried out in a long cylinder about eight feet in diameter. In this chamber any sized piece of wood, ranging from small blocks to long heavy balks, can be packed. When fully charged, the end of the cylinder is closed and secured by hold-down bolts. The chamber is then filled with the cold solution and slowly heated. Precisely how long the timber should be immersed is a matter of judgment on the part of the operator, but it has to be sufficiently long to permit the solution to permeate to the innermost cells of the wood, and to allow them to become fully saturated with the sugar. The action that takes place in the bath is that as the temperature of the solution slowly increases, the air in the wood expands, a large proportion forcing itself out of the wood into the solution, whence it escapes to the surface. Owing to the fact that the sugar boils at a point exceeding that of water, the moisture contained in the wood is converted into steam, and escapes in the same manner as the released air. The moisture and air having been completely driven out, the solution is permitted to cool, during which stage it is being constantly absorbed by the wood. In this way every cell and interstice becomes filled with sugar, and when the wood is dried, the sugar is found to be thoroughly assimilated by its tissues. Some of the sugar is so absorbed by the tissues that it cannot be readily parted from them, and the whole piece of timber is converted into a solid, homogeneous mass. When a piece of Powellized wood is examined under the microscope, no traces of the sugar are visible, either in the form of crystals or drops of syrup; the sugar is evidently in some loose molecular combination with the walls of the histological elements of the wood, as water is in the walls of living cells.

When the wood is withdrawn from the chamber, it is transported in wire caged trolleys to the drying room. The temperature of the air within this apartment is at first approximately equal to that of the wood, but it is afterward increased by the circulation of a current of hot air. When sufficient desiccation has taken place, the temperature of the chamber is slowly brought to equal that of the outer atmosphere. The wood is then ready for use. During the whole process no mechanical force of any description, either pressure or vacuum, is applied; this feature being one of the vital factors of the efficiency of the system, since there is no tendency in any way to disturb the natural fiber and tissue construction of the timber. The length of time occupied in the treatment naturally varies according to the description of wood and the dimensions of the pieces under treatment, hard-grained wood of close texture, such as Jarrah or oak, occupying longer time for complete impregnation than the common and softer woods. It generally occupies a few days, but in special cases three to four weeks may be required in the process. Although at the Powell works in London a cylindrical inclosed chamber is utilized for the boiling and saturating phases of the process, it has been found that open tanks and vats are equally serviceable and possess the additional advantage that the method can be watched much more easily and the different woods in the bath withdrawn with more facility at the moment when the impregnation was complete. Little attention is required during the boiling, it being only necessary to maintain the density of the solution at the given point; since the boiling point of the sugar solution is higher than that of water, considerable evaporation takes place, and this loss has to be compensated by the addition of more water. It is imperative that the wood should be kept entirely submerged to insure a complete treatment.

Sugar as a preserving medium has the decided advantage of being free from grit, so that it offers no more resistance to the finest and most delicate toolwork than the unpreserved timber. Furthermore, unlike creosote, it does not present a surface unsusceptible to paint or polish. Indeed, in this respect it is distinctly beneficial, as the pores of the wood are so filled up that no further stopping or priming is necessary for working. Although the sugar solution occupies the place of the sap, the specific gravity of the timber is somewhat increased. Such an increase of density has, however, many advantages in regard to hardness, toughness, tensile strength, and elasticity.

In the case of timber having "shakes" and cracks, such as develop in the natural dry seasoning of wood, the sugar acts upon these as a cement, binding the opened walls together. For this reason the Powell process is very beneficial in the preservation of ash fellies for wheels, hickory spokes, and others where thoroughly seasoned wood is essential. Moreover, in the case of pieces where veins of sapwood are present, constituting a distinct weakening of the whole section, the fault can be completely remedied, the treacherous sapwood being rendered as hard, tough, and homogeneous as the stable wood associated with it. Wood, such as spruce, which offers such difficulties to the creosoting treatment, can be as efficiently preserved as deal or pine, and also the heavier and denser timbers, oak, Jarrah, and Karri, though owing to their extreme density the period of immersion in the boiling solution is necessarily prolonged.

That the wood is thoroughly seasoned by this process is shown by the exacting tests to which it has been subjected. The boiling sterilizes the wood, while the saccharine is quite incapable of supporting or propagating the fungoid growths of "dry rot." The wood, being rendered perfectly homogeneous, neither warps nor splits. It is also non-absorbent, and is consequently immune from the changes in climatic conditions, neither expanding nor contracting under the extremes of heat or moisture. For decorative purposes it is peculiarly adapted, as the grain of the wood is closer, and by accentuating the grain and figure, it enables the cheaper qualities of the better



THE CYLINDER AND THE TROLLEY FOR CONVEYING WOOD TO THE DRYING ROOM.

woods, as the inferior mahoganies, to be employed almost as satisfactorily as the best. The sugar having efficiently stopped up the pores of the wood, a high polish can be applied to the surface.

A peculiar result of the boiling operation is the staining of the solution by the coloring matter contained in the sap, though it is not of sufficient strength to injure the natural hue of the wood. That is to say, for instance, in mahogany, while the loose coloring matter is removed somewhat, this particular wood does not become lighter in its general appearance as the result of the boiling; on the other hand,

it is darkened in precisely the manner as ensues from long exposure to the air in natural seasoning. Consequently, in the preservation of the light and white colored woods fresh solutions have to be utilized with every treatment, the stained liquid from the first bath being employed for timber where pure color is not essential, and so on until at last the bath is used for that wood used in constructional work and which is not seen.

The municipal authorities of Westminster, London, who are engaged in experiments to test the efficiencies of various woods for paving purposes, have laid a portion of Whitehall where there is considerable traffic with powellized spruce and yellow deal blocks, and the wearing qualities of the blocks are such that further sections of the roads under their control are being paved therewith. Owing to the intense solidity of the powellized wooden blocks they wear slowly, evenly, and grind up less than other woods under heavy traffic, such as that resulting from the passing of traction engines and similar heavy vehicles. Being unaffected by dampness and heat, the blocks also constantly present a uniform and closely-packed surface, while the absence of exudation from the wood renders the surface at all times perfectly clean. As sugar is completely odorless, the powellized wood is more hygienic than creosoted wooden pavements, which is a distinct advantage in hot weather, and what is far more important, these blocks possess a longer life than any of the soft woods that have hitherto been employed for this purpose.

Owing to the great penetrating power of the sugar solution, it constitutes an excellent vehicle for the conveyance of other substances into the wood, such as antiseptics, and mediums for preserving the timber against the ravages of termites, or for rendering it non-inflammable. In such cases chemicals for fulfilling these objects are mixed with the sugar solution before the wood is immersed, and in this manner these preserving agents are carried with the sugar into the interior of the wood. Powellized wood treated with chemicals for preserving it against the white ant has been employed in several countries where this pest is encountered, and though they have been laid down for over two years, and untreated wood adjacent has been completely consumed within a few weeks, the preserved timber has not been touched in the slightest by the termites.

It will be realized from the foregoing description that the process possesses many distinctive features, the most important of which are the efficient preservation of the timber so treated, the simplicity of the method, its inexpensive nature, and the expedition with which it can be carried out. The cost of the necessary plant, labor, and materials is very low, while the application of the system to newly-felled green timber constitutes a distinctive feature, as thereby the occupation of extensive and valuable storage space for the natural seasoning of wood for a prolonged period is dispensed with.

PIGEON'S STEREOSCOPE.

M. L. PIGEON sent a note to the Academy of Sciences last year on the subject of a dihedral stereoscope with a wide field and a bisecting mirror invented by him. Since that epoch, the idea has been put in industrial form, and we now find in the market apparatus of this system, of which we shall briefly recall the principle.

The two images, derived, of course, from stereoscopic negatives, are placed side by side, and between them, upon an appropriate support, is mounted a mirror. The observer places his head in such a position that his right eye sees the image before him directly, and that, at the same time, his left eye sees the other image in the mirror. As the latter has been taken upside down, it is righted by the mirror, and both eyes therefore see an image of the same direction, and, through fusion, a single image is formed, giving a stereoscopic relief.

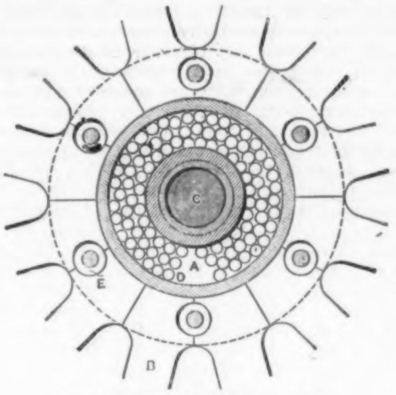
The apparatus has been brought out practically in two different models. The first, which is more especially designed for radiographic images, is constructed by MM. Radiguet and Massiot. It consists of two frames (No. 1), *D* and *E*, united by a hinge and provided with a support so arranged that it can be held in the hand or placed on a foot. They are provided with ground glasses that permit of an examination of the images by transparency. Between these two frames, and forming the bisecting plane, there is a third frame that supports a small mirror, *M*. Two slides, *A* and *B*, provided with binding screws, permit of regulating the spacing of the frames. As the principal advantage of this apparatus is that of permitting of a direct examination of an extended field, with enlargement by an optical system, the size of 7 x 9½ inches has been adopted, and there is nothing to prevent it from being constructed of larger size.

Aside from this laboratory stereoscope, MM. Roux and Marchet, of Dijon, are constructing a very cheap form of the apparatus designed for the use of the public. It is entirely of cardboard (No. 2), and the planes *A* and *B* designed to receive the images are provided with holders formed in the thickness of the board, and that permit of placing the image vertically or horizontally. The bisecting plane, *M*, which carries the mirror, is of solid cardboard, and the entire affair is very strong. When folded up it has the appearance of a drawing book. The form adopted is designed for postal cards of a size bordering on 5 x 7 inches.

The manufacturers have already issued a series of views of cities and museums. This new style of stereoscope will certainly contribute to the popularization of this branch of photography by permitting of the printing of positives cheaply and in very large number by typographic processes. This mode of printing comprises, in fact, a very fine filling which is not visible to the naked eye, but which is rendered very apparent by the optical system, which gives a more or less important magnification of the stereoscopes now in use. The effect produced by this filling thus magnified greatly injures the image, and this explains the slight success obtained up to the present time, while with M. Pigeon's new stereoscope, the filling remains invisible and the image preserves its entire beauty.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

SHOCK-ABSORBING HUB FOR MOTOR CARS.

THE Practical Engineer shows a new type of wheel hub devised to prevent destructive vibrations from



SHOCK-ABSORBING HUB.

being transmitted to the body of the vehicle from the axle. The hub, called the shock-shifting hub, is filled with steel balls loosely packed, which support the axle. The weight of the axle, carrying the vehicle, automatically forms the vacant space *A* as shown in the cut, and this space is constantly maintained when the wheel is in motion. Any shock to the wheel from the road may be considered as traveling up a spoke situated as *B*, and the ordinary course of such a shock is direct to the center of the axle *C*. Owing, however, to the mobile condition of the balls resting on one another and always ready to slip over each other, revolving on their own axes, a row of balls beneath the axle (marked *D* in the diagram) is immediately displaced. These balls are forced across the vacant space *A* and, followed by other balls, cause the shock to pass into the ball chamber in the backward moving half of the wheel. The road shock is thus broken up in its transmission, almost absorbed, and prevented from ever reaching the axle. It is claimed that the movement of the car is extremely steady, because there is no reactionary shock on the wheel such as invariably must result where springs are utilized or even where rubber alone in any form is applied to lessen the vibration.

THE INFLUENCE OF PHYSICAL CONDITIONS IN THE GENESIS OF SPECIES.*

By JOEL A. ALLEN.

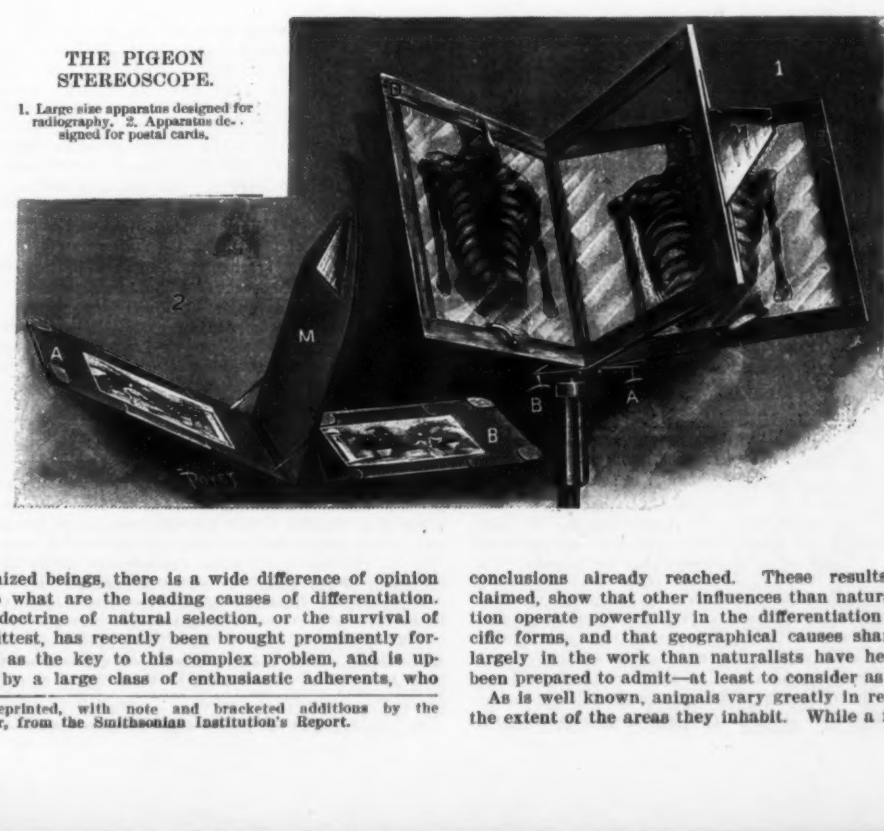
AMONG biologists who accept the modern theory of evolution as the only reasonable hypothesis available for the explanation of the diversity of structure among organized beings, there is a wide difference of opinion as to what are the leading causes of differentiation. The doctrine of natural selection, or the survival of the fittest, has recently been brought prominently forward as the key to this complex problem, and is upheld by a large class of enthusiastic adherents, who accept it as the full solution of the whole question. By others the conditions of environment are believed to be far more influential in effecting a certain class of modifications, at least, than the necessarily precarious influence of natural selection, which must take its origin in isolated instances of variation in favorable directions, and depend for its continuance upon these fortuitous advantages being inherited by the descendants of the favored individuals in which they originate. The modifying influence of conditions resulting from geographic or climatic causes was long since noticed, and for nearly a century has been considered by many writers as explanatory of much of the diversity existing not only in the human race but among animals. It has, however, remained until recently vaguely grounded, being based more in conjecture than on observed facts. Scarcely, indeed, have two decades passed since the real nature and extent of geographical variation among animals, and even as yet among only a few species, began to receive careful attention, while only within the last fifteen years has any attempt been made to correlate the observed differences with the climatic or geographical conditions of habitat. Only within recent years have the differences in general size, and in the relative size of different parts, been ascertained by careful measurement, and the differences in the character of the tegumentary covering (as the pelage in mammals) and in color, in individuals of the same species inhabiting distant portions of a common habitat, been duly recorded. In the work of registering these instructive data, it has fallen to Americans to take a leading part, large credit in the matter being due not only to the activity of our professional biologists, but to the liberality of the general government in attaching competent natural history observers and collectors to the numerous surveying parties it has sent out during the last twenty years to explore the till then practically unknown geography and productions of our western Territories.

The combined fruits of their labors, together with those of the agents and correspondents of the Smithsonian Institution, have resulted in the accumulation of an amount of material far exceeding that elsewhere accessible to single investigators, representing, as it does, at least two of the vertebrate classes of animals from the whole North American continent so fully that generalizations may be made from their study which could not otherwise have been reached for many years and for which no similar facilities for any other equal area as yet exist. The recent investigations of American mammalogists and ornithologists have been in consequence largely directed to the subject of geographical variation, and their publications teem with tabulated measurements and records of variations in form and color that accompany differences in the climatic or geographical conditions of habitat. Among the results that have followed are the discovery of numerous interesting geographical varieties or subspecies, and the demonstration of the complete intergradation of many forms, often quite widely diverse in color, size, and proportion of parts, formerly regarded (and properly so as then known) as unquestionably distinct species, which discoveries have of course necessitated a large reduction in the number of recognized "specific" or non-intergrading forms. But most important of all has been the correlation of local variations with the conditions of environment, and the deduction therefrom of certain laws of geographical variation. Upon these have been based hypotheses that go far toward explaining many of the phenomena of intergradation and differentiation observed among existing animals. In the present paper will be given not only a summary of the results thus far attained, but enough of the details of the subject to show the nature of the evidence on which rest the conclusions already reached. These results, it is claimed, show that other influences than natural selection operate powerfully in the differentiation of specific forms, and that geographical causes share more largely in the work than naturalists have heretofore been prepared to admit—at least to consider as proven.

As is well known, animals vary greatly in respect to the extent of the areas they inhabit. While a few spe-

THE PIGEON STEREOSCOPE.

1. Large size apparatus designed for radiography. 2. Apparatus designed for postal cards.



* Reprinted, with note and bracketed additions by the author, from the Smithsonian Institution's Report.

cies are nearly or quite cosmopolitan, many others are restricted to single small islands or to limited portions of a continent. Not a few range over the greater part of whole hemispheres, while by far the larger number are confined within comparatively narrow limits. Of the numerous species of mammals and birds inhabiting North America, none are equally common throughout the whole extent of the continent. The habitats of a few only extend from the barren grounds of the Arctic regions to Mexico, and from the Atlantic coast westward to the Pacific; one or two only among the mammals range over the whole continent from Alaska to Central America, while some occupy merely the extreme boreal parts of the continent. The latter, in many cases, range also over the Arctic and sub-Arctic regions of the Old World. Others extend from Arctic America southward to the United States. Still others occupy only the middle or more temperate latitudes, being unrepresented in the extreme north or the extreme south. Others, again, first appear in the middle or more southerly parts, and range thence southward far into the tropics. A large number are restricted to the region east of the Rocky Mountains; others are confined to a narrow belt along the Pacific coast; and others still to limited areas of the great Rocky Mountain plateau. In general, their distribution accords with climatal regions or zones, their respective ranges being limited in part by latitude and in part by geographical barriers, as treeless, arid plains, or high mountain ranges. The northern and southern boundaries of the habitat of a species are found to agree, not generally with the arbitrary parallels of the geographer, but with isothermal lines, these being more or less different for each species. The geographical distribution of a species is thus mainly determined by climatic or other physical causes, though in part, doubtless, by its organic constitution. In most cases species that are wide ranging are the most variable, as would naturally follow from their being subjected, in the different portions of their habitats, to widely different environing circumstances.

Hence such species are often found to run into numerous local races, some of them greatly differing from others, but still inseparably connected by individuals inhabiting the intervening regions. Over districts slightly diversified, even if of large extent, species generally preserve comparative constancy of character, while, conversely, local races are of frequent occurrence in regions of alternating valleys, mountain ranges, and table lands, and more especially is this true if the highly diversified region be situated in the warmer latitudes. Small islands, remotely situated from other lands, have usually many species peculiar to themselves, their differentiation being proportionate to the geologic antiquity of the islands and their remoteness from larger land areas. In islands of recent origin and not widely separated from continental lands, the ancestral stock of the species is still often clearly apparent, the forms thus differentiated through insular influences not having passed beyond the varietal stage; in other cases they are specifically different from their nearest continental allies, or may even have advanced far toward generic distinctness, while their origin may still remain tolerably apparent.

Plasticity, or susceptibility to the influences of physical surroundings, often differs even among quite closely allied species, as those of the same family or even genus, and different species are evidently affected differently by the same circumstances. Variability in color may or may not accompany variability in size or in the character of particular organs. Generally, however, a species which varies greatly in one feature varies to a similar degree in many others. Species having a wide geographical range not only commonly run into a greater or less number of local races, but they generally present more than the average amount of strictly individual variation, as though species ranging widely in space were originally more plastic than those having more circumscribed habitats, and were thus able more easily to adapt themselves to their surroundings; they are also more persistent, their fossil remains being far more frequently met with in the quaternary deposits than are those of the more local and generally more specialized forms.

Geographical variation, as exhibited by the mammals and birds of North America, may be summarized under the following heads, namely, (1) variation in general size, (2) in the size of peripheral parts, and (3) in color, the latter being subdivisible into (*a*) variation in color with latitude and (*b*) with longitude. As a rule, the mammals and birds of North America increase in size from the south northward. This is true not only of the individual representatives of each species, but generally the largest species of each genus and family are northern. There are, however, some strongly marked exceptions, in which the increase in size is in the opposite direction, or southward. There is for this an obvious explanation, as will be presently shown, the increase being found to be almost invariably toward the region where the type or group to which the species belongs receives its greatest numerical development and where the species attain the largest size, and are also most specialized. Hence the representatives of a given species increase in size toward its hypothetical center of distribution, which is in most cases doubtless also its original center of dispersal. Consequently there is frequently a double decadence in size within specific groups, and both in size and numerically in the case of species when the center of development of the group to which they belong is in the warm temperate or tropical regions. This may be illustrated by reference to the distribution of the higher classes of vertebrates in North America. Among the species occurring north of Mexico there are very few that may not be supposed to have had a northern origin; and the fact that some are circumpolar in their distribution while most of the others (especially among the mammals) have congeneric Old World allies further strengthens the theory of their northern origin. Not only do individuals of the same species increase in size toward the north, but the same is true of the species of the different genera. Again, in the exceptional cases of increase in size southward, the species belong to southern types, or, more correctly, to types having their center of development within or near the intertropical regions, where occur not only the greatest number of the specific representatives of the type, but also the largest.

For more detailed illustration we may take three families of the North American Carnivora—namely, the Canidæ (wolves and foxes), the Felidæ (lynxes and wildcats), and the Procyonidæ (raccoons). The first two are to some extent cosmopolitan, while the third is strictly American. The Canidæ have their largest specific representatives the world over, in the temperate or colder latitudes. In North America the family is represented by six species,[1] the smallest of which, speaking generally, are southern and the largest northern. Four of them are among the most widely distributed of North American mammals, two, the gray wolf and the common fox, being circumpolar species; another, the Arctic fox, is also circumpolar, but is confined to high latitudes. The three widest-ranging species—the gray wolf, the common fox, and the gray fox—are those which present the most marked variation in size. Taking the skull as the basis of comparison, it is found that the common wolf is fully one-fifth larger in the northern parts of British America and Alaska than it is in northern Mexico, where it finds the southern limit of its habitat. Between the largest northern skull and the largest southern skull there is a difference of *about 35 per cent of the mean size!* Specimens from the intermediate region show a gradual intergradation between these extremes, although many of the examples from the upper Missouri country are nearly as large as those from the extreme north.

The common fox, though occurring as far north as the wolf, is much more restricted in its southward range, especially along the Atlantic coast, and presents a correspondingly smaller amount of variation in size. The Alaskan animal, however, averages about one-tenth larger than the average size of specimens from New England. In the gray fox, whose habitat extends from Pennsylvania southward to Yucatan, the average length of the skull decreases from about five inches in Pennsylvania to considerably less than four in Central America—a difference equal to about 30 per cent of the mean size for the species.

The Felidæ, unlike the Canidæ, reach their greatest development, as respects both the number and the size of the species, in the intertropical regions. This family has but a single typical representative—the panther (*Felis concolor*)—north of Mexico, and this ranges only to about the northern boundary of the United States. The other North American representatives of the family are the lynxes, which, in some of their varieties, range from Alaska to Mexico. They form, however, the most northern as well as the most specialized or "aberrant" type of the family. While they vary greatly in color as well as in the length and texture of the pelage at different localities, they afford a most remarkable exception to all laws of variation in size with locality; for a large series of skulls, representing localities as widely separated as Louisiana, northern Mexico, and California on the one hand and Alaska and the Mackenzie River district on the other, as well as various intermediate localities, reveals no appreciable difference in size throughout this wide area. The true cats, however, as the panther and the ocelots, are found to greatly increase in size southward or toward the metropolis of the family. The panther ranges from the Northern States southward over most of South America. Skulls from the Adirondack region of New York have an average length of about 7½ inches, the length increasing to 8¾ in Louisiana and Texas, from beyond which points there is lack of data. The ocelot (*Felis pardalis*) finds its northern limit near the Rio Grande, of Texas, and ranges thence southward far into South America. The average size of Costa Rican examples is about one-fifth greater than that of specimens from the Rio Grande.

The Procyonidæ are chiefly represented in tropical America, a single species—the common raccoon (*Procyon lotor*)—being found in the United States, and thence northward to Alaska [=British Columbia]. Here again the increase in size is southward or toward the metropolis of the family—Pennsylvania specimens averaging about one-tenth smaller than Costa Rican examples.

The common otter (*Lutra canadensis*) affords another example of increase in size southward among our Carnivora, although belonging to a family essentially northern in its distribution. The otters, however, form a distinct subfamily, which attains its greatest number of species in the warmer regions of the earth, and hence offers not an exception to, but a confirmation of, the law of increase toward the center of distribution of the group to which it belongs.

Instances of increase in size northward among the Carnivora of North America are so generally the rule that further space need not be taken in recounting examples in detail. It may suffice to state that the badger, (*Taxidea americana*), the marten (*Mustela americana*), the fisher (*M. pennanti*), the wolverine (*Gulo luscus*), and the ermine (*Putorius erminea* [=*longicauda, cicognanii, noveboracensis*, etc.])—all northern types—afford examples of variation in size strictly parallel with that already noticed as occurring in the foxes and wolves.

To refer briefly to other groups, it may be stated that the Cervidæ (deer family) are mainly rather northern in their distribution; that the largest species occur in the colder zones, and that individuals of the same species increase rapidly in size toward the north. Some of the species in fact afford some of the most striking instances of northward increase in size, among which are the common Virginia deer and its several representatives in the interior of the continent and on the Pacific slope. It is also noteworthy that the most obviously distinctive characteristic of the group—the large, annually deciduous antlers—reaches its greatest development at the northward. Thus all the northern species, as the moose, the elk, and the caribou, have branching antlers of immense size, while the antlers are relatively much smaller in the species inhabiting the middle region of the continent and are reduced to a rudimentary condition—a simple slender sharp spike, or a small and singly forked one—in the tropical species, the antlers declining in size much more rapidly than the general size of the animal. This is true in individuals of the same species as well as of the species collectively.

The Rodentia (the squirrels, marmots, spermophiles, mice, and their affines) offer the same illustrations in respect to the law of increase in size as the species already mentioned, the size sometimes increasing to the southward, but more generally to the northward, since the greater number of the species belong decidedly to northern types. There is no more striking instance known among mammals of variation in size with locality than that afforded by the flying squirrels, in which the northern race is more than one-half larger than the southern; yet the two extremes are found to pass so gradually the one into the other that it is hardly possible to define even a southern and a northern geographical race except on the almost wholly arbitrary ground of difference in size. The species, moreover, is one of the most widely distributed, ranging from the Arctic regions (the northern limit of forests) to Central America.

Among birds the local differences in size are almost as strongly marked as among mammals and, in the main, follow the same general law. A decided increase in size southward, however, or toward the warmer latitudes, occurs more rarely than in mammals, although several well-marked instances are known. The increase is generally northward and is often very strongly marked. The greatest difference between northern and southern races occurs, as in mammals, in the species whose breeding stations embrace a wide range of latitude. In species which breed from northern New England to Florida the southern forms are not only smaller, but are also quite different in color and in other features. This is eminently the case in the common quail (*Ortyx virginianus*), the meadow lark (*Sturnella magna*), the purple grackle (*Quiscalus purpureus*), the red-winged blackbird (*Agelæus phœniceus*), the golden-winged woodpecker (*Colaptes auratus*), the towhee (*Pipilo erythrophthalmus*), the Carolina dove (*Zenædura carolinensis*), and in numerous other species, and is quite appreciable in the blue jay (*Cyanurus cristatus*), the crow (*Corvus americanus*), in most of the woodpeckers, in the titmice, numerous sparrows, and several thrushes and warblers, the variation often amounting to from 10 to 15 per cent of the average size of the species.[2]

As a general rule certain parts of the organisms vary more than does general size, there being a marked tendency to enlargement of peripheral parts under high temperature or toward the tropics; hence southward in North America. This is more readily seen in birds than in mammals, in consequence mainly of their peculiar type of structure. In mammals it is manifested occasionally in the size of the ears and feet and in the horns of bovines, but especially and more generally in the pelage. At the northward, in individuals of the same species, the hairs are longer and softer, the under fur more abundant, and the ears and the soles of the feet better clothed. This is not only true of individuals of the same species, but of northern species collectively, as compared with their nearest southern allies. Southern individuals retain permanently in many cases the sparsely clothed ears and the naked soles that characterize northern individuals only in summer, as is notably the case among the different squirrels and spermophiles.

In mammals which have the external ear largely developed, as the wolves, foxes, some of the deer, and especially the hares, the larger size of this organ in southern as compared with northern individuals of the same species is often strikingly apparent. It is more especially marked, however, in species inhabiting extensive open plains and semidesert regions. The little wood hare, or gray "rabbit" (*Lepus sylvaticus*),[3] affords a case in point. This species is represented in

[1] The gray wolf (*Canis lupus* [=*C. occidentalis* and allied forms]), the prairie wolf (*C. latrans* [now treated as a group of a dozen or more closely related species and subspecies]), the Arctic fox (*Vulpes lagopus* [now separated into several forms]), the common fox (*V. alopex* [=*V. fulvus* and numerous related forms]), the kit fox (*V. velox* [now subdivided into several forms]), and the gray fox (*Urocyon virginianus* [=*U. cinereoargenteus*, with a dozen or more subspecies]).

[2] The modern equivalents of several of the technical names in this paragraph are as follows: *Ortyx* [=*Colinus*] *virginianus; Quiscalus purpureus* [=*quiscula*]; *Zenoedura carolinensis* [=*Zenaidura macroura*]; *Cyanurus* [=*Cyanocitta*] *cristata; Corvus americanus* [=*brachyrhynchos*].—Author's note, 1906.

[3] The group here referred to as *Lepus sylvaticus* has in recent years been divided into some twenty-five or more forms, mostly with the rank of subspecies.—Author's note, 1906.

some of its varieties across the whole breadth of the continent and from the northern border of the United States southward to Central America, but in different regions by different geographical races or subspecies. In addition to certain differences of color and general size, the ears vary still more strongly. In the form inhabiting the Great Plains, commonly known as the little sage brush hare (*L. sylvaticus nuttalli*), the ears are considerably longer than in the eastern variety and increase in size from the north southward, reaching their greatest development in western Arizona and the desert region farther westward and southward, where the variety of the plains proper passes into still another variety characterized mainly by the large size of its ears, which are in this race nearly twice the size they attain in the eastern variety. In the large long-eared "jackass" hares of the plains the ear likewise increases in size to the southward. In *Lepus callotis*,[4] for example, which ranges from Wyoming southward far into Mexico, the ear is about one-fourth to one-third larger in the southern examples than in the northern. The little brown hare of the Pacific coast (*L. trowbridgei*) presents a similar increase in the size of the ear southward, as does to a less extent the prairie hare (*L. campestris*). Not only are all of the long-eared species of American hares confined to the open plains of the arid interior of the continent, but over this same region is the tendency to an enlargement of the ear southward stronger than elsewhere. It is also of interest in this connection that the largest-eared hares of the Old World occur over similar open, half-desert regions, as do also the largest-eared foxes. On our western plains the deer are represented by a large-eared species. Among the domestic races of cattle those of the warm temperate and intertropical regions have much larger and longer horns than those of northern countries, as is shown by a comparison of the Texan, Mexican, and South American breeds with the northern stock, or those of the south of Europe with the more northern races. In the wild species of the Old World the southern or subtropical are remarkable for the large size of their horns. The horns of the American pronghorn (*Antilocapra americana*) are also much larger at southern than at northern localities.[5] Naturalists have also recorded the existence of larger feet in many of the smaller North American mammalia at the southward than at the northward among individuals of the same species, especially among the wild mice, in some of the squirrels, the opossum, and raccoon, as well as in other species.

In birds the enlargement of peripheral parts, especially of the bill, claws, and tail, is far more obvious and more general than in mammals. The bill is particularly susceptible to variation in this regard, in many instances being very much larger, among individuals of unquestionably the same species, at the southward than at the northward. This accords with the general fact that all the ornithic types in which the bill is remarkably enlarged occur in the intertropical regions. The southward enlargement of the bill within specific groups may be illustrated by reference to almost any group of North American birds, or to those of any portion of the continent. As in other features of geographical variation, the greatest differences in the size of the bill are met with among species having the widest distribution in latitude. Among the species inhabiting eastern North America we find several striking examples of this enlargement among the sparrows, blackbirds, thrushes, crows, wrens, and warblers; in the quail, the meadow lark, the golden-winged woodpecker, etc. Generally the bill in the slender-billed forms becomes longer, more attenuated, and more decurved (in individuals specifically the same) in passing from the New England States southward to Florida, while in those which have a short, thick, conical bill there is a general increase in its size, so that the southern representatives of a species, as a rule, have thicker and longer bills than their northern relatives, though the birds themselves are smaller. There is thus not only generally a relative, but often an absolute, increase in the size of the bill in the southern races. The species of the Pacific coast and of the interior afford similar illustrations, in some cases more marked even than in any of the eastern species. More rarely, but still quite frequently, is there a similar increase in the size of the feet and claws.

The tail, also, affords an equally striking example of the enlargement of peripheral parts southward. Referring again to the birds of the Atlantic coast, many of the above-named species have the tail absolutely longer at southern localities than at northern, and quite often relatively longer. Thus, while the general size decreases, the length of the tail is wholly maintained, or decreases less than the general size; but in some cases, while the general size is one-tenth or more smaller at the south the tail is 10 to 15 per cent longer than in the larger northern birds. Some western species are even more remarkable in this respect, and in consequence mainly of this fact the southern types have been varietally separated from the shorter-tailed northern forms of the same species.

Variations in color with locality are still more obvious, particularly among birds in which the colors are more positive, the contrasts of tint greater, and the markings consequently better defined than is usually the case in mammals. The soft, finely divided covering of the latter is poorly fitted for the display of the delicate pencilings and the lustrous, prismatic hues that so often characterize birds. Mammals, however, present many striking instances of geographical variation in color.

(To be continued.)

[4] *Lepus callotis*, as now recognized, does not occur north of Mexico; in place of this name may be substituted *Lepus texianus* and its subspecies.—Author's note, 1906.

[5] The deer tribe, in which the antlers increase in size toward the north, offer an apparent exception to the rule of increase in size of peripheral parts toward the Tropics. The antlers of the deer, however, are merely seasonal appendages, being annually cast and renewed, and are thus entirely different physiologically from the horns of bovines, which retain a high degree of vitality throughout the life of the animal.

SCIENCE NOTES.

Replying to a question on the subject asked by Deputy Rampoldi, the Under Secretary of Public Instruction said in the Chamber recently that the government was willing to accept suggestions regarding the excavations at Herculaneum, but intended to reserve to itself the entire initiative, regarding the work in the light of a national undertaking. The work will not be begun immediately owing to obstacles offered by the village of Resina. When the question was studied and the expenditure ascertained, a bill would be presented to Parliament. The statement was applauded, but it is admitted that the government lacks the means and energy to expedite the work. Hence Herculaneum may remain buried for another generation.

That very superior glass can be made by melting quartz crystal, and so cooling it as to prevent recrystallization, has been known to scientists for some time, but as quartz glass was obtainable only in the form of minute globules by means of an expensive process, the knowledge has never been turned to practical account. Dr. Day, of the Carnegie Geophysical Laboratory in Washington, while experimenting recently with quartz in the electric furnace, incidentally discovered a method of producing quartz glass in larger quantities, obtaining perfect plates of it six inches long and two inches wide. Possessing certain remarkable and valuable properties peculiar to no other kind of glass, this substance is actually worth its weight in gold, and the importance of Dr. Day's discovery may be imagined. Expansion of quartz glass when heated is imperceptible, and cold water may be poured over it when white hot without breaking it. Ordinary glass refuses to transmit the ultra-violet rays of the spectrum, while quartz glass transmits it freely. It is the best of material for camera and telescope lenses, owing to its exceeding clarity, and its use is expected to immensely widen the scope of astronomical research, especially in observing the spectra of remote stars.—Bulletin of the New York Edison Company.

In an article on Halley's Comet, which Mr. F. W. Henkel, F.R.A.S., writes for Knowledge, he states the latest results of the determinations made on the date of its probable return. On this investigation Messrs. Cowell and Crommelin are at present engaged, and they have arrived at the conclusion that May 10, 1910, is the correct date within a month for the next perihelion passage. In view of some rather foolish prognostications which have been made of late regarding the collision of comets and the earth, it is interesting to note that though the motion of a comet is greatly affected by the proximity of a planet, the planet itself is entirely unaffected. Thus the comet of Lexell approached so closely to the planet Jupiter that, had its masses been in any way considerable, both that planet and its satellites would have had their orbits completely changed, the comet's distance from Jupiter being, when nearest, less than that of the fourth satellite (the furthest of those discovered by Galileo in 1610). Nevertheless, not the smallest measurable derangement was observed, so that the mass of the comet must have been much less than that of any of these satellites. This seems to be a general rule, no perturbations due to the proximity of a comet having been ever perceived for any planet. Yet the real volume of some comets being at times greater than that of the sun itself, the density of the materials composing them must be extremely low.

Messrs. Bourquelot and Herissey, of Paris, obtain a new product from a Madagascar plant which they call *bakankosine*. It comes from the grains of the *Strychnos Bakanko*, which are about the size of a small hazel nut. Some of the grains are half-round and flat on one side, but most of them have an irregular shape. In order to prepare this product, the grains have their outer covering removed and are then ground in a mill to a coarse powder. This is treated by ether so as to remove the fatty matter and is then exhausted hot by alcohol at 95 degrees C. in a continuous apparatus. The alcoholic solution is distilled under reduced pressure in the presence of a little calcium carbonate, after which the residue is taken up by water. After filtering a small amount of yeast is added to destroy the cane sugar. In twenty-four hours the solution is again filtered and is evaporated to a sirupy consistence. Soon the bakankosine is deposited in the form of large colored crystals, which are then dried. The crystals are re-dissolved and further purified. Such crystals lose 4.81 per cent of water when heated to 115 or 120 deg. C. As to the properties of the new product, it is obtained in large crystals which are quite stable in the air and they are colorless, odorless and have a bitter taste. This substance melts the first time at 157 deg., then becomes solid and melts partially a second time at about 200 deg. It is somewhat soluble in water and alcohol when cold and much more so at a higher heat, but is scarcely soluble in acetic acid. Ether will hardly dissolve it. This body does not seem to be poisonous, and it could be given in hypodermic injection to guinea-pigs without causing any bad effect.

ENGINEERING NOTES.

It has been estimated that if we allow $2,500 as total cost of 100 horse-power producer erected; three hours labor per day required by the producer; the engine operating ten hours a day, 300 days per year; interest, depreciation and taxes 15 per cent; engine requiring 12,000 B.T.U. on full load; then in a town where 13,000 B.T.U. anthracite coal may be bought for $6 per ton, the 600 B.T.U. gas must be sold at 27½ cents per 1,000 cubic feet to meet the competition of 100-horse-power producer plant when the engine carried full load 10 hours per day and 300 days per year.

The use of superheated steam should be desirable in connection with the operation of heavy freight trains over mountain grades, where it is necessary that the boiler stresses and the use of fuel and water should be reduced to the minimum, and in services where frequent stops and starts are made it also has an advantage, through small loss by condensation, when the steam comes in contact with cold cylinders. The dryness of the steam is a positive advantage through the absence of expense for maintenance due to the working of water through valve chests and cylinders.

It is a peculiar function of a fan blower that instead of always delivering a fixed volume of air, regardless of requirements, it automatically increases the volume as the resistances are decreased. On the other hand, if the blower be in operation with a fairly free outlet, in excess of its capacity area, and that free area be decreased, the pressure produced will immediately rise, thus tending at once to overcome the increased resistance. Therefore, if a certain maximum pressure is known to be required, the fan may be so speeded as to give this at such times as the conditions demand; while at other times, when less pressure or volume of air is required, proper manipulation of the blast gate will economize power.—American Machinist.

Feed-water may be heated in two or three ways: first, by means of the exhaust steam, which, coming from a non-condensing engine, is capable of heating the feed water to 212 degrees and of saving say twelve to fifteen per cent as compared with feeding cold water. For large plants where it would pay to use induced draft to make up for the loss in temperature of the chimney gases, which produce the draft, it will undoubtedly pay to use an economizer, but as this apparatus is expensive both in first cost and up-keep, the amount saved in utilizing the waste gases from a small plant would probably not offset the outlay. The closed type of feed-water heater is about as efficient as the open type, provided the water is pure and it avoids trouble from pumping hot water, but the open type is frequently made use of to assist in purifying the water and, if properly managed, may give good service in that respect. For condensing engines a primary heater of the closed type may be installed between the engine and condenser, which will help to condense the steam and heat the feed water to a low temperature, say 130 to 140 degrees Fahrenheit. A secondary heater, either of the closed or open type, may be used to heat the feed water to a still higher temperature, say 212 degrees, by the use of the exhaust from the feed and air pumps, which can not be used more profitably than in this way, as all the heat is returned to the boiler.

There are many causes of the rusting of iron. It may be produced by atmospheric action alone, but in a majority of cases galvanism plays a large part in the destruction of the metal. Long experience has shown how rapidly iron nails employed in fastening sheets of lead and copper upon roofs are destroyed, the other, the electro-negative metal, remaining comparatively unaffected. The electrolyte, or exciting fluid, which by acting on the iron and not on the other metal or by acting more upon the former than upon the latter, causes the electric current, is water from rain or snow or the vapor always present in the air. The decomposition of the water causes the liberation of oxygen at the positive pole, which is the iron, and this nascent oxygen rapidly combines with the iron. Now, it is claimed that red lead is an excellent material for protecting iron from rust and electrical action. Unfortunately, however, red lead is more electro-negative to iron than either copper or lead. Hence, should moisture by any chance get between the red lead and the iron, the destruction by rust is more rapid than when iron is in contact with copper or lead. This electrochemical action is at the same time strengthened by the purely chemical action between the red lead and the carbonic acid always present in the air, an action which converts the red lead into ceruse, whereby an additional quantity of nascent oxygen is set free to rust the iron. It is also highly probable that the carbonic acid has an independent action upon the iron, thereby much facilitating its oxidation. It must not be forgotten that every porous place and still more every crack in the paint becomes sooner or later an entrance for water and carbonic acid. A good oil varnish is by far the best protection for iron, but it must, of course, be properly used. Not only must the iron be scrupulously, practically, and chemically clean and dry when the varnish is applied, but the covering must be without a flaw. Varnish will not adhere to greasy, rusty, or wet iron, and the contraction of the varnish on drying will cause minute cracks at such places and the iron-destroying gases will find their way through these cracks and get between the iron and the non-adherent varnish. Again, the varnish must be thoroughly dry before the iron is exposed to the weather. The varnish may be colored if the color does not inter-

fere with the strength, continuity, and elasticity of the protecting skin, but is best dispensed with.—Architectural Art.

ELECTRICAL NOTES.

A project is on foot for organizing a new transportation line between Berlin and St. Petersburg, in which electric traction will figure to a large extent. This consists in running an electric railway between Stockholm and a port lying on the south coast of Sweden, for instance Trolleberg, and a steam ferry would be run between the latter port and Sassnitz on the German coast, passing by the island of Rügen, then from the German port there would be an electric railroad leading to Berlin. On the other hand, a steam ferry line would be established between Stockholm and the port of Abo, in Finland, from whence an electric railway would pass to St. Petersburg. It is estimated that the time needed for the trip between the two terminal points, Berlin and St. Petersburg, would be reduced in this way to twenty hours, while at present the same traject by the Eydtkuhnen route requires thirty-one hours.

It is reported that the Telefunken Company, which is the leading radio-telegraphic company in Germany, has been making an extensive series of trials upon a new system of wireless telephony, and it is claimed that they were able to use the telephone in this way between their Berlin office and the new radio-telegraphic post erected at Nauen, making a distance of about 24 miles. Using a small mast fixed upon the company's building in the city and taking but a small amount of current, they were able to clear the distance between the two points and exchange conversation to some extent. The reports do not mention as yet the details of the process nor describe the apparatus which is used in the present case, but it appears that selenium is not employed, at any rate. According to the company's statements, all existing radio-telegraphic posts can be equipped for wireless telephony within the proper limits by employing the new Schloemilch receiver. As to the transmitter, it consists of the usual transmitter to which is added some small auxiliary apparatus.

The Electrical World announces that Mr. F. J. Tone, of the Carborundum Company, has designed a furnace for the production of metallic silicon. The difficulty is that the temperature of reduction is very close to the temperature of volatilization. The electric furnace must, therefore, permit of very close regulation of temperature. A special type of resistance furnace is used which is now in commercial operation at the works of the Carborundum Company. One of the chief problems in connection with metallic silicon is now to find a market for it. Metallic silicon may be used to some extent in the steel industry as a substitute for ferro-silicon, but for most purposes in the steel industry ferro-silicons are preferred. Carborundum has been tried before as a substitute for ferro-silicon in the manufacture of steel. The advantage is that the material contains some 62 per cent silicon, which is more than the content of silicon in ferro-silicons made in the blast furnace, but carborundum has two distinct disadvantages for steel manufacture. One is that it contains some 30 per cent of carbon, which is not wanted in the steel; the other is that at the temperatures ordinarily used in the manufacture of steel, the bath will absorb only limited quantities of silicon from carborundum. In view of these facts an indirect use of carborundum for steel manufacture suggested itself—namely, as a starting material for making ferro-silicon. When heated to a high temperature in an electric furnace, a mixture of iron and carborundum reacts in such a way that the silicon alloys with the iron, and the carbon is thrown out as graphite. Now this carbon may be utilized for the production of further amounts of ferro-silicon. For this purpose the carbon is employed as a reducing agent for silica and iron oxides. The charge then consists of iron carborundum, silica, and iron oxide, and the products of the reaction are ferro-silicon and carbon dioxide, which is set free.

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